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Yellow Cypress: Can We Grow It? Can We Sell It?

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Yellow Cypress: Can We Grow It? Can We Sell It?

Proceedings of a Symposium
26–28 March 1990
at the Richmond Inn, Richmond, B.C.

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Theme: Is there potential for more extensive yellow cypress silviculture in the Pacific Northwest?

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Special thanks are also extended to Kathy Banky for her tireless efforts in helping me organize and deliver this workshop, and for her constant cheery disposition while dealing with the logistical problems which inevitably arise in arranging workshops. She deserves the credit for a "glitch-free" workshop.

The organization of the workshop was assisted immeasurably by the capable and ready co-operation and assistance of Margot Spence and Angela von Sacken from "FRDA-Central" at the Research Branch.

As usual, a workshop or conference cannot succeed without:

1. the efforts of the speakers, who provided the necessary and excellent content, displayed generally good visuals, and kept to their time limits;
2. the efforts of members of the discussion panel, who provided us with a comprehensive overview of their operational experience;
3. the efforts of the discussion group leaders, who patiently facilitated the dialogue and bravely provided summaries of the group discussions; and, especially,
4. the attention, motivation, co-operation, tolerance and good cheer of the participants of the workshop.

This workshop has been another example of a FRDA legacy for researchers: do not underestimate the value of operational input in determining research priorities, in interpreting research results, and in monitoring trials.

J. Daniel Lousier, Editor
Extension Co-ordinator
Coastal FRDA Extension, Demonstration,
Research & Development

YELLOW CYPRESS SYMPOSIUM

AGENDA

DAY 1 — March 26, 1990

1800–2200	Registration, no-host bar, poster session, product displays

DAY 2 — March 27, 1990

0830–0840	Welcoming remarks

SESSION 1: YELLOW CYPRESS – PRODUCTS AND MARKETING

0840–0910	Keynote address: Bill St. John, MacMillan Bloedel Ltd., Vancouver, B.C.
0910–0935	Product delivery: George Malpass, Primex, Richmond, B.C.
0935–1000	Wood properties: Les Josza, FORINTEK, Vancouver, B.C.
1000–1030	Break
1030–1055	Existing and future products: Barry Tyrer, Trans-Pacific Trading, Vancouver, B.C.
1055–1120	Cultural views: Glen Bonderud, MacMillan Bloedel Ltd., Vancouver, B.C.
1120–1200	Discussion
1200–1300	Lunch

SESSION 2: YELLOW CYPRESS – BIOLOGY, ECOLOGY, AND REGENERATION

1300–1330	Keynote address: Paul Alaback, U.S. Forest Service, Juneau, Alaska
1330–1355	Ecology of yellow cypress sites: Karel Klinka, University of British Columbia and Ministry of Forests, Vancouver, B.C.
1355–1420	Reproductive biology – pollen/seed/seed orchards Anna Colangeli, Department of Biology, University of Victoria, Victoria, B.C.
1420–1445	Physiological and environmental tolerances of yellow cypress: Steve Grossnickle, B.C. Research, Vancouver, B.C.

SESSION 2: YELLOW CYPRESS – BIOLOGY, ECOLOGY, AND REGENERATION (cont'd)

1445–1515	Break
1515–1540	The genetics of yellow cypress: John Russell and Charlie Cartwright, Cowichan Lake Research Station, Ministry of Forests, Mesachie Lake, B.C.
1540–1605	Diseases, insects and animal damage of yellow cypress: Paul Hennon, U.S. Forest Service, Juneau, Alaska
1605–1630	Operational use of yellow cypress in coastal British Columbia: John Barker, Western Forest Products Limited Vancouver, B.C.
1630–1700	Discussion
1700–2130	No-host bar, poster session, product display
1830–1930	Stand up supper

DAY 3 — March 28, 1990

0800–0810	Chairman's remarks: Dan Lousier
0810–0915	Panel discussion: Regeneration experiences Panel composed of silviculturists with regeneration experience in managing yellow cypress: John Barker, Gabriella Sartisohn, John McClarnon, and Jack Dryburgh Facilitators: Glen Dunsworth and Dan Lousier
0915–1100	Working group discussions Topics include: (1) silviculture and site recommendations (2) sustainable high-value products (3) research needs
1100–1150	Working group summary reports
1150–1230	Wrap-up speaker: Glen Dusnworth

YELLOW CYPRESS SYMPOSIUM

POSTERS AND DISPLAYS

1. Operational Micropropagation of Yellow Cedar.
   Chern-Hsi Ling. Sponsors: CANFOR and Clay's Nurseries.
2. Provenance and Family Variations in Yellow Cypress.
   Marilyn Cherry.
3. Yellow-Cedar Steckling Nursery Production.
   Don Carson and Craig Ferguson, Cowichan Lake Research Station,
   Ministry of Forests, Mesachie Lake, B.C.
4. Delta Cedar Products — Product Display.
5. Yellow Cypress Clonal Forestry.
   John Russell, Cowichan Lake Research Station.
   Ministry of Forests, Mesachie Lake, B.C.
6. Yellow Cypress Plantations in Sub Montane Ecosystems.
   Steven Joyce, Western Forest Products.
7. Yellow Cypress Growth in Relation to Prescribed Fire Intensity.
   Bill Beese, MacMillan Bloedel Ltd.
8. Stock Quality Improvement of Yellow-Cedar.
   Steven Grossnickle, B.C. Research.
9. S&R Sawmills — Product Display.
10. Hinoki and Yellow Cypress Samples for Comparison.
    MacMillan Bloedel Ltd.

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SESSION 1

YELLOW CYPRESS: PRODUCTS AND MARKETING

Keynote Address

Bill St. John
MacMillan Bloedel Ltd.
Vancouver, B.C.

As a simple little lumber salesman, I'm really not sure what I can say in response to your theme "Is there potential for more extensive yellow cypress silviculture in the Pacific Northwest?"

However, I can answer the second question stated in your title ("Can we sell it?") with a resounding yes.

What I will try to do this morning is deal with the manufacturing and marketing of yellow-cedar. I will start with some historical background, talk about where we are at today, and then take a look at where I think we will go in the future.

With all the benefit of hindsight, and speaking very frankly as an industry, I think we have done an absolutely abysmal job of managing our cypress resource, which on a per-cubic metre basis is the most valuable resource in our forests. We have treated this high valued specialty as a commodity.

In saying this, I am not being critical of the people who have been involved, because the problem has been with the system more than with the people. Let me explain: Until the early 1980's our industry was almost entirely volume driven, and yellow-cedar, which accounts for only 0.67% of our forest resource, was considered a nuisance species to be disposed of as quickly and easily as possible. Furthermore, the Japanese were prepared to pay a high price for yellow-cedar logs and just selling the logs was an easy and profitable way out.

Unfortunately, while this approach was easy and profitable, it put the control of the market in the hands of the Japanese custom cutters who were more interested in their own profit than in increasing the value of the species.

In the early eighties, the industry started to do its own custom cutting of the species, almost entirely into large cants which were exported to Japan. Some companies have stuck with this approach while others have found it more profitable to go back to selling all their logs to the highest bidder.

In the case of MacMillan Bloedel, we started custom cutting in 1983 and today consume all of our sawable (about 80% of our total yellow-cedar) in our own custom cutting department. Today our highest quality logs are cut at a small Japanese sawmill that we have under contract in Surrey. Our mid-quality logs are custom sawn at S & R mills and our smaller logs are now consumed in our own New Westminster mill where they are made into finished construction products for the Japanese markets.

All of this production is sold by our custom cutting department here in Vancouver, which is part of our marketing department. Japan is by far the major market, but Taiwan is starting to take an increasing share.

In Japan, we are the only lumber company with our own distribution company, MBBM Japan, and all of our yellow-cedar sales go through this distribution company rather than through the traditional Japanese trading companies. This puts us closer to the final consumer and gives us better control over the price we can achieve. Most importantly, it gives us much better market and product knowledge.

Now where will we go in the future? Our objective is to continue to refine and improve our product mix to come closer to making the final products that the end-user wants.

We have been experimenting with different sawing patterns and with making more sophisticated high-value products at the Hokushin mill in Surrey which I referred to earlier. We have no definite plans at this time, but I suspect it is only a question of when, not if, we will build our own mill as the next step.

With the increasing costs the Japanese sawmill industry is facing and the ever-tougher log export controls, we expect we will see some Japanese investment in similar mills in British Columbia to take advantage of those who still want to sell logs rather than become involved in the processing and manufacture of yellow-cedar.

I would like to have seen us move faster than we have, but at least we have been moving in the right direction. I believe we will continue to do so and that we will gradually learn to manufacture and market a much more sophisticated product mix that will pay us a much higher return.

You've all heard a great deal about so-called "added value." Yellow-cedar probably has a greater potential for adding value than any other species in our forests.

What is value? Is it cost? Is it the ability to satisfy a need? No, it is the buyer's perception of worth. It can be as much status as real worth.

The challenge we in marketing face is to create a perception that yellow cypress has a greater value than it presently has in the minds of the buyer.

Is it realistic to think we can do this? I believe it is. Why is it realistic? Because it is a better wood than the species it competes with. Compare yellow-cedar to hinoki: yellow-cedar is half the price; it has all heart wood versus sapwood; and it has grain texture.

Why is yellow-cedar half the price? We have been willing to accept it because we did not know any better and it was a better price than we could get anywhere else. Hinoki is also important in Japanese mythology.

What do we need to do to capture this value?

1. Make more finished products rather than leave the extra margin for the Japanese remanufacturer. Big chunks of yellow-cedar have no value to the consumer.
2. Know the value of our product and do not sell it for less.
3. Take control of the yellow-cedar fibre supply and not leave it in the hands of others.
4. Promote, stressing value and prestige (e.g., using cuts of yellow-cedar in temple construction).

I believe we can accomplish these objectives if we take a long-term approach. It won't be easy and it will cost more in the short term. But in the long term, it will be worth it.

However, if you are going to replant yellow-cedar I would like to offer the following suggestions:

- Clear fibre is worth many times more than knotty fibre and pruning is something that should be considered.
- Stain is quite common in this species and is a defect. Is there some way it can be eliminated?
- Close grain is much admired; thus, artificially stimulated growth is not advisable.

Should we replant cypress? A tough question to answer because it will take 100+ years to grow to maturity and who knows what the world will want then?

If I had to make the decision, I think I would replant only on a site-specific basis.

The species has value today because of some of its unique characteristics. These characteristics may not have the same value 100 years from now and it would probably be safer to plant with other species that have a potentially wider range of end uses.

Thank you.

Product Delivery

George Malpass
Primex
Richmond, B.C.

By way of introduction, let me describe our company and our role in the yellow cypress industry in British Columbia. As a company, we do no logging and we buy 100% of our logs on the open market. Because yellow cypress is a minor species on the coast, no one company has large concentrations of it in its cutting areas. Thus, the product tends to be logged in conjunction with other species and sold on the open log market. We have been purchasing yellow cypress on the open market and processing it at our Field Sawmills Division, in Courtenay, since 1974. We process annually 175 000 m^3 or approximately 18% of the B.C. cut — 175 000 m^3/yr for 16 years and I do not believe I have ever seen a second-growth cypress log — I am not sure I want to.

The total standing inventory of yellow cypress on the B.C. coast is estimated at 160 million m^3, or approximately 160 years, of cutting at the current annual rate of harvest. In any assessment of yellow cypress, it is very important to recognize grade differences in the species. No species anywhere has the range of value by grade of log that yellow cypress has. This range of log values is very critical in understanding the economics of processing yellow cypress.

I am not sure of the audience's familiarity with B.C. log grade distinctions so, for simplicity, let me categorize the grades as:

1. pulp wood;
2. small wood (under 1 m^3 log average per stem);
3. standard sawlogs; and
4. high grade sawlogs.

The values today, for example, might be in the following range:

1. pulp wood - \$20–40/m^3;
2. small logs - \$40–60/m^3;
3. standard sawlogs - \$70–250/m^3; and
4. high grade - \$300–500/m^3.

Thus, it is important to understand that the so-called high value of yellow cypress is really limited to the top 50% of the harvest, and that the qualities that command these values relate to old-growth characteristics of fine grain and clear wood content.

Because yellow cypress is a high-elevation species, logging costs will be on the upper end of the cost range on the coast. The economies of delivering the logs to market thus depend on the quality of the stand to a much greater degree than for other species. Pulp and small log prices rarely cover the cost of logging. So, if you like, the sawlog content subsidizes the removal of small logs and pulp wood.

The small logs are also old growth, however, and do have certain desirable characteristics. The ability of the species to resist rot and insect damage makes it an ideal product for outdoor use and for use in areas susceptible to rot. We process small log cypress into Japanese Dodai, or foundation sills, and this product competes primarily with pressure-treated hemlock.

The small log yellow cypress, therefore, produces a product of higher value than hemlock but, because it tends to be more defective in nature than hemlock, it does not command a price any greater than hemlock in a small log form. The defective nature of the wood means higher sawmill operating costs, lower recovery, and lower grades in lumber. The pulp wood content of cypress has traditionally commanded a very low price because yellow cypress wood chips have always been priced very low. The

fibre density and brightness of yellow cypress, however, are very good and the potential for pulping should not be underestimated. The low cypress chip prices are a result of problems of mixing a minor species with other chips rather than any inherent characteristics in the chip.

In the past, stumpage policy has not recognized the tremendous price spreads by grade in yellow cypress and has had the effect of creating a disincentive for the removal of the small wood from the cutting area. I believe that is now being addressed under current changes to harvesting regulations, but in the past, the stumpage plus the incremental logging cost was almost always higher than the value of the small wood.

I will listen with interest to Mr. Jozsa from Forintek and his discussion of yellow cypress wood properties, particularly those of second growth. Second-growth cypress cannot replace the products currently being produced from the sawlog portion of old growth. However, if second growth has the preservative characteristics of old-growth small wood, it could continue to be a valuable species for foundation sill and outdoor uses. Furthermore, a managed second-growth forest could produce a more uniform log which would greatly enhance its value from a recovery and productivity point of view. Pulping characteristics will, of course, also be important. However, it is hard to imagine that a high cost, high-elevation product could compete as pulp wood with low-elevation, low cost and faster-growing species.

One further point on the economics of processing our existing yellow cypress resource: Old-growth yellow cypress, remains a very desirable product, particularly in Japan where it is similar to some Japanese native species. The fact that the volume of old-growth yellow cypress harvested should remain constant for a great number of years will result in further investment in refining the manufacturing process and this will certainly enhance the value of the old-growth resource. This future enhanced value will help compensate for the higher delivery costs from more remote and costly logging areas.

Japan will continue to set the market for yellow cypress. The great old-growth forests of hinoki and hiba are essentially cut, but the Japanese continue to admire the characteristics of these materials. The closest species is yellow cypress and it is available commercially only from B.C. and Alaska. The sawlogs are cut to extract the highest possible content of clear fibre which is used for joinery purposes such as doors, mouldings, and exposed beams and also in temple restoration. As I mentioned previously, the small log production is used for foundation sills and hidden structural members.

With the strength of the Japanese economy and the Japanese love of wood, I see a continuing market for these products. We should be aware, however, that Japan has a huge forest resource. Japan annually consumes approximately 42 million m^3 of sawlogs, in addition to 7.5 million m^3 of imported lumber. Of the 42 million m^3 of sawlogs they consume, approximately 20 million m^3 are harvested from their own forest, with the balance imported from Southeast Asia, North America and the Soviet Union. The imported volume of sawlogs is certainly decreasing, particularly from Southeast Asia. Canadian log exports are coming to an end and the Soviets face a huge range of economic problems in Siberia. This bodes well for the increased importation of lumber from North America.

However, what about Japanese ability to increase harvesting of their own forests? The 20 million m^3 they harvest is not much below the B.C. coastal harvest and, in theory, it could be increased dramatically.

The factors that keep the harvest from increasing in Japan are as follows:

- a strong currency, combined with high logging costs, that makes logs very costly;
- a desperate labour shortage;
- increasing environmental pressures; and
- lack of thinning (because of funding and labour problems) that has reduced sawlog values.

They also made some mistakes in species selection by planting heavily to sugi (red cedar) which is not in strong demand in second growth.

They do, however, have huge second-growth forests of hinoki, which are a potential threat to yellow cypress, particularly to small log yellow cypress and certainly to second-growth yellow cypress in the future. I would suggest that no study of the economics of yellow cypress planting in the future would be complete without a close look at the Japanese situation.

The special characteristics of yellow cypress are going to lead to new opportunities in other markets as well. With more and more apprehension over the use of chemicals as wood preservatives, new markets are opening up every year for yellow cypress. Certain jurisdictions in the U.S. and Europe are banning preservatives for use in schools and public recreational areas and I am sure our other speakers will be expanding on some of these points.

In conclusion, I would like to reiterate my main points on the economics of delivering yellow cypress to the market.

1. At the current rate of harvesting, the old growth should continue for many years.
2. The characteristics of the high grade old growth are what currently make the harvesting of yellow cypress economically viable (i.e., the top 50% of the yellow cypress harvest). The value of this old-growth sawlog will ensure that the yellow cypress log can continue to be economically delivered to market.
3. Second-growth products in the future cannot be compared to those from the old-growth forest because of totally different characteristics. Old-growth values versus the second-growth values will have a much bigger impact on product values than for other species.
4. The major market for yellow cypress will continue to be Japan; however, its huge resource of hinoki should be taken into account in any economic modelling of a second-growth yellow cypress forest.

Thank you and I welcome any questions.

Yellow Cypress Wood Properties

Abstract

L.A. Jozsa
Forintek Canada Corp.
Vancouver, B.C.

Yellow cypress has enjoyed a most favourable status in recent years. Good quality logs and lumber command premium prices on international markets. Reforestation policies have embraced yellow cypress, and the number of seedlings planted is up as well. Unfortunately, there is very little baseline information about basic wood properties for the species and, as a rule, it has very slow growth rates. The wood has very good machining properties and it is naturally durable. It is not known what impact rapid growth rates will have on wood quality. Low-elevation plantations are capable of producing rapid growth. Information is needed about the basic wood properties and how they might change with rapid growth rates.

Yellow Cypress Wood Quality and The Hinoki Connection*

L.A. Jozsa
Forintek Canada Corp.
Vancouver, B.C.

Circumstances that span an ocean and link two cultures have proved beneficial to the British Columbia forest industry. In Japan, overcutting of a native tree species, Japanese hinoki (*Chamaecyparis obtusa*), has opened a market for yellow cypress, a tree species found only on the coastal slopes and islands of the Pacific Northwest.

A study was initiated at Forintek Canada Corp. to examine the basic physical and chemical properties of yellow cypress wood produced by relatively slow-grown and fast-grown trees. At present, there is very little baseline information on wood quality of the species. We do know that slow-grown old-growth yellow cypress wood has exceptional machining properties. Such wood is close grained, evenly textured, and naturally durable. Good quality lumber commands premium prices on international markets. Yellow cypress represents 7% of the volume harvested on the Coast, but it makes up 14% of the value. Average log price is about $\$150/m^3$, ranging from \$50 to $600/m^3$, depending on quality.

Wood quality is an important consideration in decisions regarding investment in forest management. Some of these considerations for yellow cypress include: maintaining a sustainable supply for the future market (globally, B.C. is well situated to grow this resource); maintaining its value (many important growth parameters can now be manipulated to ensure specific wood properties); and expanding its range (planting trees off-site). Reforestation policies have embraced yellow cypress and the number of seedlings planted is up. It has been found that low-elevation plantations are capable of producing rapid growth (Fig. 1). Information is needed now about the basic wood properties and how they might change with accelerated growth rates. An appreciation of the relative value of wood characteristics is critical to intelligent forest tending and management decisions. Specifically, the following selected wood quality characteristics must be examined:

1. wood density and density uniformity (tree-to-tree, pith-to-bark, and base-to-top of the stem density variability, and within annual ring density uniformity);
2. natural durability of wood (nootkatin and chamic acid contents; these chemical extractives act as "built-in" natural fungicides and insecticides);
3. dimensional stability (excessive longitudinal shrinkage was noted in compression wood, while normal wood is very stable).

Sample material was collected from an old-growth (about 320 years old, DBH 50 cm), a second-growth (about 100 years old, DBH 50 cm) and a plantation-grown stand (16 years of age, DBH 11 cm). Figure 1 shows examples of ring width patterns. The plantation-grown example shown is from the stump section of one of the most vigorous trees.

Wood density variation is being examined from these stands because density is generally considered to be the single most important indicator of clear wood quality. According to published reports, yellow cypress has a wood density equivalent to that of western hemlock (about $0.42\ g/cm^3$). It is also known that yellow cypress wood is tough and strong, yet it machines extremely well (e.g., saws, planes, sands, turns, carves, etc.). What is not so well understood is the *density uniformity* within individual annual rings, because of the technical difficulty in measuring intra-ring density profiles. X-ray densitometry techniques are being used to depict density uniformity with a resolution of 0.2 mm. Figure 2 shows intra-ring density profile summaries for an average annual ring of old-growth yellow cypress, compared with that of Douglas-fir and western redcedar.

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* Prepared for the Yellow Cypress Working Group Newsletter, February 1991.

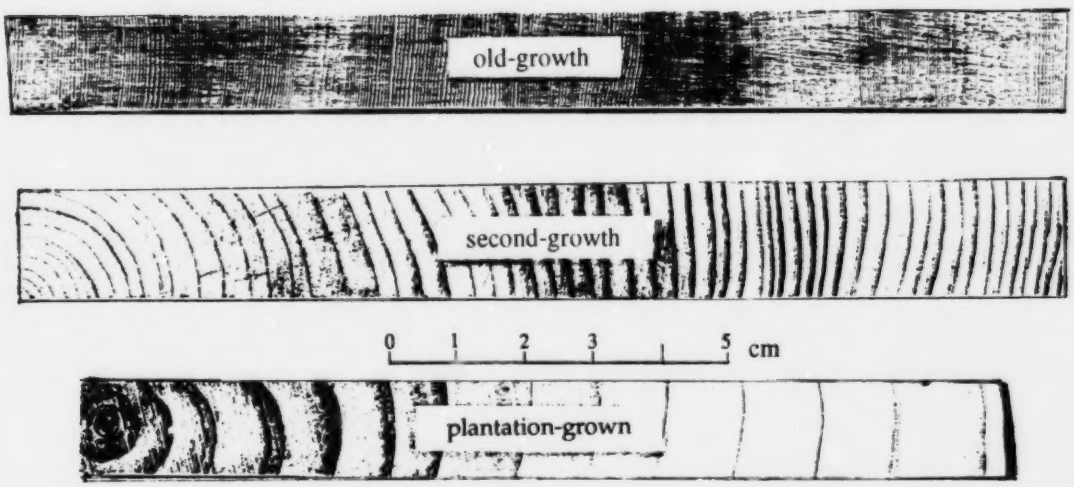

FIGURE 1. Comparison of ring width patterns from old-growth, second-growth, and plantation-grown yellow cypress.

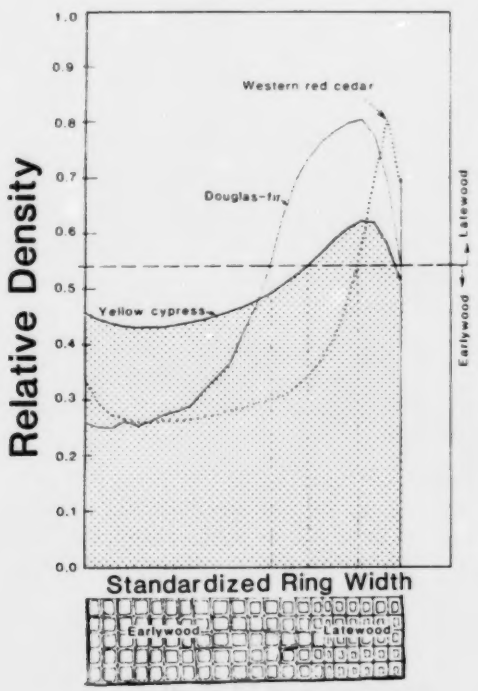

FIGURE 2. Intra-ring density profile comparison of old-growth yellow cypress with Douglas-fir and western redcedar.

Each profile is the average of about 100 annual rings from three random examples of old-growth trees. Note density range and proportion of earlywood and latewood. It may seem incredible, but the relative density range is identical in this example for western redcedar and Douglas-fir (from about 0.25 to 0.80 g/cm^3), while the yellow cypress density gradient is from 0.43 to 0.62 g/cm^3. Based on this example, and on previous work done at Forintek, we can say that old-growth yellow cypress is the most homogeneous commercial softwood species in Canada. Low density latewood and high density earlywood in the yellow cypress annual ring explains why there is so little figure in edge-grained or flat-sawn lumber. This density uniformity lends a certain toughness and a homogenous texture to the wood, making it ideal for higher value products (e.g., carving stock, turned products, joinery and veneers). When considered along with mean density, homogeneity provides an index to the type of conversion processes and products most suitable for yellow cypress wood. Therefore, *density uniformity* will be an important characteristic to maintain in determining yellow cypress wood quality.

The primary objective of this study was to determine whether average density and density uniformity are maintained in second-growth and plantation-grown yellow cypress trees. Although X-ray densitometric data acquisition has not been completed on all samples, we can provide a "sneak preview" of the plantation-grown trees sampled near Mesachie Lake. Figure 3 shows the average intra-ring density profile of about 500 annual rings at BH from 21 plantation-grown trees (DBH 11 cm, age at BH 13 years, ring width 4.2 mm, and average relative density 0.43). As these results show, both average density and density uniformity of the wood had been maintained by these "off-site" trees in spite of their very rapid growth rate. These results are very encouraging in showing product suitability of rapidly grown yellow cypress.

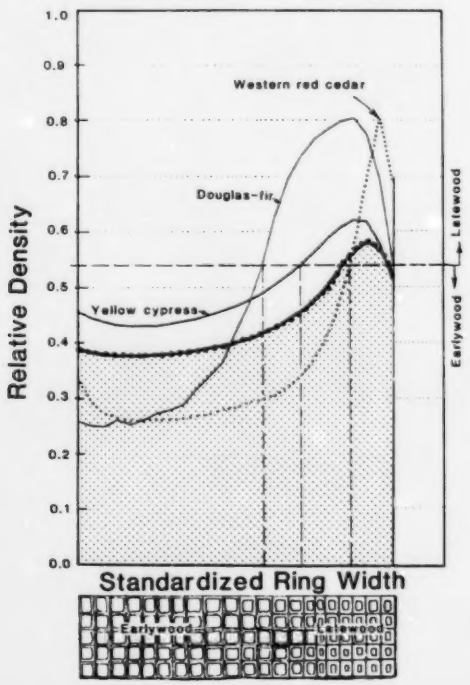

FIGURE 3. Intra-ring density profile comparison of plantation-grown vigorous yellow cypress with old-growth yellow cypress, Douglas-fir and western redcedar.

In fact, it is the product suitability that made yellow cypress acceptable in the Japanese market, filling the void left by the over-exploitation of Japanese hinoki. Hinoki is one of the most valuable of Japanese timbers. Because of overcutting, the standing volume is not large. These trees grow between 1300 and 2900 m above sea level (a high altitude tree, similar to yellow cypress). The wood has very fine, uniform texture and straight grain, medium weight, and an average relative density of 0.40 g/cm^3, not unlike yellow cypress. The wood of hinoki is one of the most highly prized woods for both interior and exterior use in house and temple construction.

In order to gauge density uniformity, a random sample of hinoki 4 x 4's was measured by X-ray densitometry. About 30 rings were scanned from pith-to-bark and the results are shown in Figure 4. The average relative density of the 30 rings was 0.40 g/cm^3, and the average ring was 2.6 mm wide. The rings were made up of 77% earlywood (average relative density of 0.37 g/cm^3), and 23% latewood (average relative density 0.54 g/cm^3) by width.

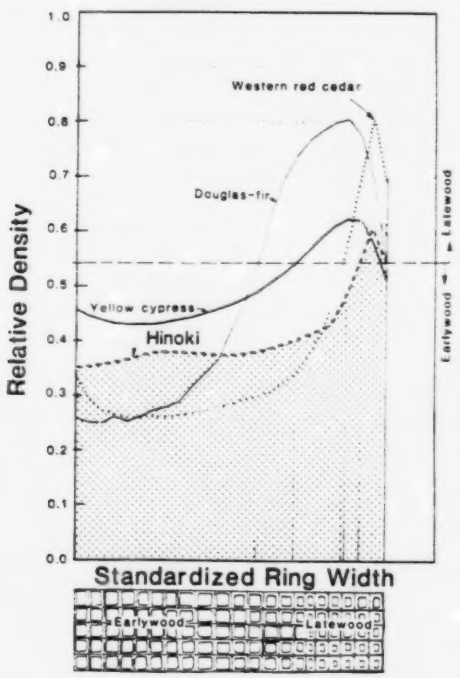

FIGURE 4. Intra-ring density profile comparison of Japanese hinoki with three old-growth B.C. woods.

This comparison helps us to understand why yellow cypress wood is an excellent substitute for hinoki, having very similar average density and density uniformity. Of course, there are other wood quality attributes and characteristics that were not discussed here. They include physical properties (such as branch size, stem taper, spiral grain and wood colour) and chemical properties (such as extractives content and natural resistance to decay and insects). Developing such a knowledge base will help us to link the characteristics of the resource to potential processing and marketing decisions.

YELLOW CYPRESS TRIVIA*

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Did you know?

. . . . that the oldest living thing known to man, a 5200-year-old bristlecone pine tree (*Pinus longaeva* D.K. Bailey), was inadvertently cut in 1964 near Ely, Nevada?

Today, the oldest living tree known to man is a 4600-year-old bristlecone pine. This tree grows in the White Mountains of northeastern California, in a grove of old trees, near timberline at about 3000 m elevation. It is a small tree, stunted, and distorted. More than half of its bole has been lost to dieback and wind erosion.

The oldest bristlecone pines are living ruins, and they do look as if they are. Their trunks, 3–10 m high, are little more than eroded stumps. Yet each possesses its life line, a few centimetres of wide, bark-covered growing tissue, from partly bare roots to a thin crown of branches. The discovery of these "giant bonsai" was documented in the March 1958 issue of the *National Geographic Magazine*.

In Canada, the oldest living trees grow on Vancouver Island and on the west side of the south coast mountains. In one way or another, this region is more suitable than the rest of Canada for the development of trees with extended life spans. Specifically, some of the key factors that contribute to longevity are the less frequent occurrence of destructive forest fires and strong winds (such as typhoons and hurricanes that weaken forest communities in other temperate regions), and the genetic potential of certain tree species.

To my knowledge, the record tree ages documented in western Canada are as follows:

- 1600-year-old yellow cypress near Campbell River, B.C.
- 1307-year-old Douglas-fir near Duncan, B.C.
- 920-year-old western larch near Cranbrook, B.C.
- 730-year-old Engelmann spruce in the Canadian Rockies at the Columbia Icefields, Alta.
- 684-year-old Douglas-fir near Banff, Alta.
- 637-year-old white spruce near Coppermine River, N.W.T. This sampling area is near the northern tree-line.

The above list is a brief summary of my documented experience with old trees. In other words, I have the wood samples and I have counted the annual rings.

In addition to these trees, there are potentially older ones whose age cannot be determined because of butt rot or extremely slow growth rate. For example, subalpine larch trees growing in Manning Park could be into their third millennium of growth (described in the October 1990 issue of *The Forestry Chronicle*). In contrast to bristlecone pine relics, the old trees in southwestern B.C. can grow to substantial size. Figure 1 shows a yellow cypress tree with butt rot which could be 2000 years of age. Figure 2 shows a 1200-year-old yellow cypress tree with a large bole and a live crown. This tree grows about 11 km from downtown Vancouver, and one can drive right up to it.

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* Prepared for the Yellow Cypress Working Group Newsletter, February 1991.

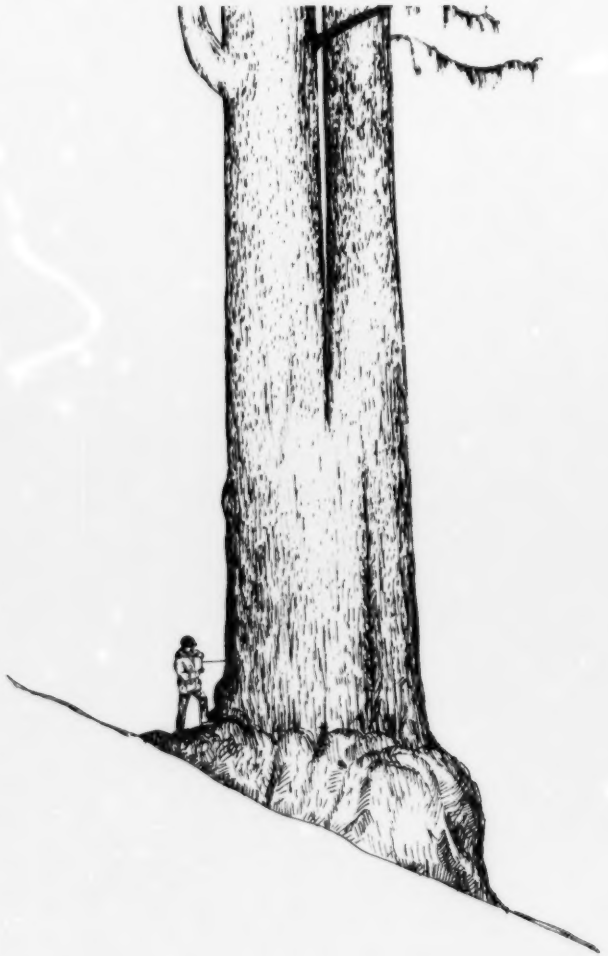

FIGURE 1. Yellow cypress tree near Campbell River. Diameter is 3.3 m above the butt swell. Unfortunately, this tree has a hollow centre because of butt rott.

FIGURE 2. Yellow cypress tree near Vancouver at Cypress Provincial Park, with 2.96 m DBH and of about 1200 years of age.

In conclusion, it is very likely that there are much older trees in Canada than the ones reported here, because "the absence of evidence is not the evidence of absence." Still, I expect that the oldest living tree in Canada is a yellow cypress because of the harsh environmental conditions in its natural range, because its wood has natural durability, and because I am a fan of yellow cypress.

Existing And Future Products

Barry Tyrer and Jack McLeod
Trapa Forest Industries, Ltd.
Richmond, B.C.

Ladies and gentlemen:

Today I have been asked to speak about existing and future yellow-cedar (cypress) products.

By way of background, this year marks the 25th year for our company, Trans-Pacific Trading, to be engaged in the manufacture and export of yellow-cedar to Japan.

The first year of statistics that I was able to obtain listing the imports of logs and lumber into Japan was 1955. That year no yellow-cedar lumber was imported, however, 5000 m^3 of cypress and 41 000 m^3 of Port Orford cedar logs were imported.

In fact, total lumber imports of West Coast softwoods amounted to only 64 000 m^3, and total log imports were only 91 000 m^3. Today these figures have increased to approximately 4 million m^3 for lumber and 9 million m^3 for logs. Clearly the demand and consumption by the Japanese for British Columbia softwoods is enormous.

With specific reference to yellow-cedar, 700 m^3 was imported in 1956. By 1966, the year we began manufacturing and exporting to Japan, exports of yellow-cedar lumber had reached 20 000 m^3. Growth in sales for all members of the British Columbia coastal sawmill community reached 308 000 m^3 by 1988 and recent preliminary figures published by the Council of Forest Industries of British Columbia indicate that 1989's exports will be close to this volume again. Yellow-cedar currently makes up about 8% of British Columbia's exports to Japan by volume, but represents almost 15% by value. Equally important is that more than 96% of yellow-cedar manufactured in British Columbia is exported to Japan.

Because of the importance of this market, my talk will concentrate on the specific uses of yellow-cedar in the Japanese market. This is not to dismiss the market opportunities available both domestically and in the United States, Europe and other parts of Asia. It is only to focus our attention on the largest and single most important market for this durable and beautiful species.

Japan's equivalent to yellow-cedar is hinoki. Yellow-cedar is an excellent substitute for hinoki as the two bear many similar characteristics. Yellow-cedar is resistant to rot and beetle infestation and need not be chemically treated as does hemlock. It is strong and durable and is excellent material in house construction. Its rich yellow colour and pleasant aroma add to the attractive interior decorating of a typical Japanese home.

Generally speaking, hinoki is a very expensive product for the average Japanese home, having been grown in many cases on private plantations. An extensive reforestation program begun in Japan immediately following World War II will eventually produce more and more hinoki for the domestic Japanese housing market. Because of the relatively slow-growing characteristics of this species and, with the exception of thinnings, major exploitation of hinoki is not expected to take place until well into the 21st century — at least 20 years from now.

A description of cypress lumber, of the sizes cut and the use and application, will help to illustrate current and future demand.

- 10 1/4 inch/wider clears and factory flitches, special high + 8 3/4 inch grade lumber remanufactured into a variety of specific sizes for interior decorating whether as a solid piece of lumber or as laminated veneer.
- 5" x 5"/wider clears and flitches — again, this lumber is remanufactured into door frames, windows, etc

- 5" x 5" square pillars and base posts depending on the quality of the post, clear or merchantable, the post will be exposed or covered.
- 4 1/4" x 4 1/4"/wider similar use as 5 x 5/wider
- 4 1/4" x 4 1/4" similar to 5 x 5
- 2" x 3"/wider and utility through clear is all remanufactured
  1 1/2" x 3"/wider into window frames, door trims or any other area that might be exposed to moisture.
- 1 1/8" x 3"/wider core lumber for laminated posts.

As you can understand, the vast majority of yellow-cedar sold to Japan is used in various stages of house construction. And so, as the demand for houses has grown, so too has the demand for yellow-cedar.

The current number of housing starts in Japan has averaged 1.6 million units per year over the past few years. Of this number, approximately 45% have been wooden single family dwellings. Japanese statistics can be somewhat confusing as a "house start" is actually a living unit (i.e., a concrete apartment building with 500 units is 500 starts or houses). Nonetheless, even in this context of concrete homes, yellow-cedar is used for interior decorating. The traditional Japanese bathroom (this means a bathing room) frequently is finished with yellow-cedar doors, door jambs, windows and trim. A discouraging note, however, is that fewer and fewer typical Japanese style homes are being built, fewer tatami rooms and fewer shoji screens, with more and more "western" (as it were) features becoming part of the finishing.

In a nutshell, as the future of the Japanese housing industry develops, so too goes the demand for yellow-cedar from British Columbia.

What are the limiting factors for the future growth of the yellow-cedar industry? Well clearly, as we depend so heavily on the Japanese market, if housing demand fell, prices paid for yellow-cedar would fall. Curiously, however, as soon as prices fall, regardless of the number of housing starts, consumption picks up which tells us that yellow-cedar is a preferred product for house construction, and that probably its only limiting factors are supply and affordability.

Alternative markets, both domestic and abroad, are markets for the future and price is the only limiting factor. There is domestic demand for the species in uses such as greenhouses, gazebos, fences, stadium and park benches and cross arms for utility poles.

Recent environmental concerns in countries such as Germany might, over time, see an increase in demand. For example, plastic window frames have been a substitute for wood until recently, when certain groups who do not consider plastic as environmentally friendly are pressing for a return to wood. Furthermore, certain African and Asian species are now considered endangered and governments are therefore not permitting the import or use of certain species unless it can be determined that a species is not endangered and is being cut on a sustained yield basis.

In summary, the future for yellow-cedar should be of considerable interest to British Columbia. Because of the unique properties of the species, because it is a favoured species in house construction in Japan, and because it is peculiar to the Pacific Northwest, yellow-cedar will continue to enjoy its special niche in the market.

SESSION 2

YELLOW CYPRESS: BIOLOGY, ECOLOGY, AND REGENERATION

Keynote Adress

Yellow Cypress: An Overview of Biology and Evolution

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In this section of the conference the central question is: Can we grow yellow cypress? First, we need to know what yellow cypress really is. This requires knowledge of three principal areas: 1) evolutionary biology including biogeography, history and genetics; 2) physiology: growth and reproductive potential; and 3) ecology: how does it grow under current environmental conditions, and what constricts it (e.g., soils, pathogens, insects, competition by both trees and shrubs)?

In terms of evolutionary biology, yellow cypress can be viewed as a stress tolerator (*sensu* Grime 1979) and as a K-selected species. Compared to other conifer species, especially those of the more typical Pinaceae, *Chamaecyparis* allocates more energy to defences and, therefore, less energy to reproduction and growth (Loehle 1987). This carbon allocation strategy leads to low mortality, long life, and less consistent reproductive success than is typical of most other conifer groups. A consistent strategy of the Cupressids in general seems to be that of tolerating suboptimal environmental conditions rather than competing with other trees on fertile, well-drained sites. Cypress, then, is greatly influenced by soils, climate and other abiotic factors by virtue of its dominance in extreme sites.

Yellow cypress is an ideal species for studying the influence of global climatic change on northern ecosystems. From ecophysiological studies, it has been shown that it quickly slows photosynthesis and growth when moisture or nutrients become limiting, and is thus highly sensitive to subtle climatic changes. Studies of the width and density of its rings may hold important clues to past climatic fluctuations in the northern rainforest environment. Because of inconsistent reproductive success, its present geographic distribution may be a reflection of recent glacial history, especially on the mainland. It occurs in a series of disjunct populations in both its range in Prince William Sound, Alaska and its southernmost range in the central Cascades of Oregon.

Chamaecyparis is a small genus of recent origin with most species having a severely restricted geographic distribution. Only six species exist, three in Taiwan and central Japan, two in northwestern North America, and one in eastern North America. All occur in mild, wet, oceanic climates with transient snow (except for *C. thyoides*). All occur in mixture with other tree species and generally in wetland or wetland-upland ecotones where nutrient availability is low. The closely related genus *Cupressus* includes 12 species in Mediterranean climates of Europe and the southwestern United States. Most of these species occur in severe environments often with chronic disturbance such as wind, flooding or fire.

A persistent problem with the maintenance or expansion of yellow cypress populations has been poor reproductive success. In Alaska, for example, mixed yellow cypress/western hemlock forests often change to pure hemlock following clearcut logging. Laboratory experimentation (G. Pawuk, pers. comm., N.E. For. Exp. Sta. USDA For. Serv.) has revealed that seeds require an extended warm stratification followed by a cool stratification to stimulate germination. Cone maturation can be 1 or 2 years, depending on environmental conditions. Problems of natural seedling establishment can mostly be overcome through artificial regeneration by transplanting seedlings grown either from seed or cuttings. Because the natural range of cedar may be just an artifact of reproductive vicissitudes, its ecologic and economic importance could be greatly enhanced with artificial regeneration.

Chamaecyparis generally occurs on the edges of bogs or at high elevations (although not necessarily at timberline) where it often assumes a shrub lifeform. Plantings in England and the Southern Hemisphere also show that the tree can change physiognomy and structure, depending on soil nutrient and drainage conditions. It is particularly sensitive to droughty or peaty soils. It is generally devoid of insect

and disease problems, except for the puzzling decline that started a hundred years ago in parts of Southeast Alaska.

We are only now beginning to understand what yellow cypress really is. Few studies have been conducted on this species and much needs to be accomplished before a quantitative assessment of its management potential can be made over the diverse array of environments in which it may potentially thrive. The high value of yellow cypress as finished wood products, as wildlife forage, and as a way to diversify less productive sites all provide compelling reasons to promote the species in new forest plantations throughout its natural range.

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Ecology of Yellow-Cedar Sites

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SUMMARY

Yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) is distributed predominantly in the Pacific region of western North America. It occurs as a dominant, but is more commonly a scattered species in a variety of ecosystems in the Mountain Hemlock (MH) zone and in the wetter Coastal Western Hemlock (CWH) subzones of coastal British Columbia*. The ecosystems that were found to support even the marginal growth of the species are used to outline ecological quality of "yellow-cedar sites." It would be incorrect, however, to assume that the observed occurrence of yellow-cedar in old-growth ecosystems is sufficient to identify all yellow-cedar sites, as many factors may have determined the present distribution pattern of the species.

A recently completed ecological site classification for coastal B.C. by the Ecological Programme Staff of the B.C. Ministry of Forests delineated site associations — that is, groups of ecologically equivalent sites with similar potential vegetation and productivity. To acquire an integrated overview, site associations were plotted on a chart, exemplifying the relationships of potential climax vegetation to the three basic components of ecological site quality: climate, soil moisture, and soil nutrients (Banner *et al.* 1990) (Fig.1). The chart is used to indicate the natural occurrence of yellow-cedar in relation to recognized site associations, and uses the measure of relative importance from 0 to 100. The resulting pattern of importance values is used to characterize (1) ecological quality of yellow-cedar sites and (2) ecological amplitude and growth-site relationships of yellow-cedar.

Importance values decreased in order from the MH zone to the very wet CWH subzones to the wet and moist CWH subzones and then to the dry and very dry CWH subzones (i.e., along a climatic gradient of increasing temperature and decreasing precipitation) (Fig. 2). The bold fonts below indicate the segment with the highest importance value. Considering only continentality (Fig. 3), importance values decreased in order from hypermaritime to maritime to submaritime climates. These trends corroborate Krajina's (1969) conclusion that yellow-cedar is adapted to (or productive yellow-cedar sites are located in) very humid (rainy or snowy) climates with relatively warm winters and cool summers.

In relation to a soil moisture gradient, importance values increased from moderately to slightly to fresh to moist to **very moist** to wet soil sites (Fig. 4). In relation to a soil nutrient gradient, importance values decreased from **nitrogen-poor** (including very poor, poor, and medium soil nutrient regimes) to nitrogen-rich (including rich and very rich soil nutrient regimes) (Fig. 5). These trends suggest that yellow-cedar, like ecologically related western redcedar, exhibits a wide edaphic amplitude. Krajina (1969) concluded that the most productive growth of yellow-cedar occurs on very moist and nitrogen-very rich sites in the montane very wet maritime CWH variant where it grows in competition with amabilis fir (*Abies amabilis* Dougl. *ex* Loud. Forbes). As the nitrogen-rich and very rich soils are uncommon on high-elevation coastal sites, it is difficult to extrapolate with certainty the growth improvement of yellow-cedar beyond the nitrogen-medium soils (Fig. 6).

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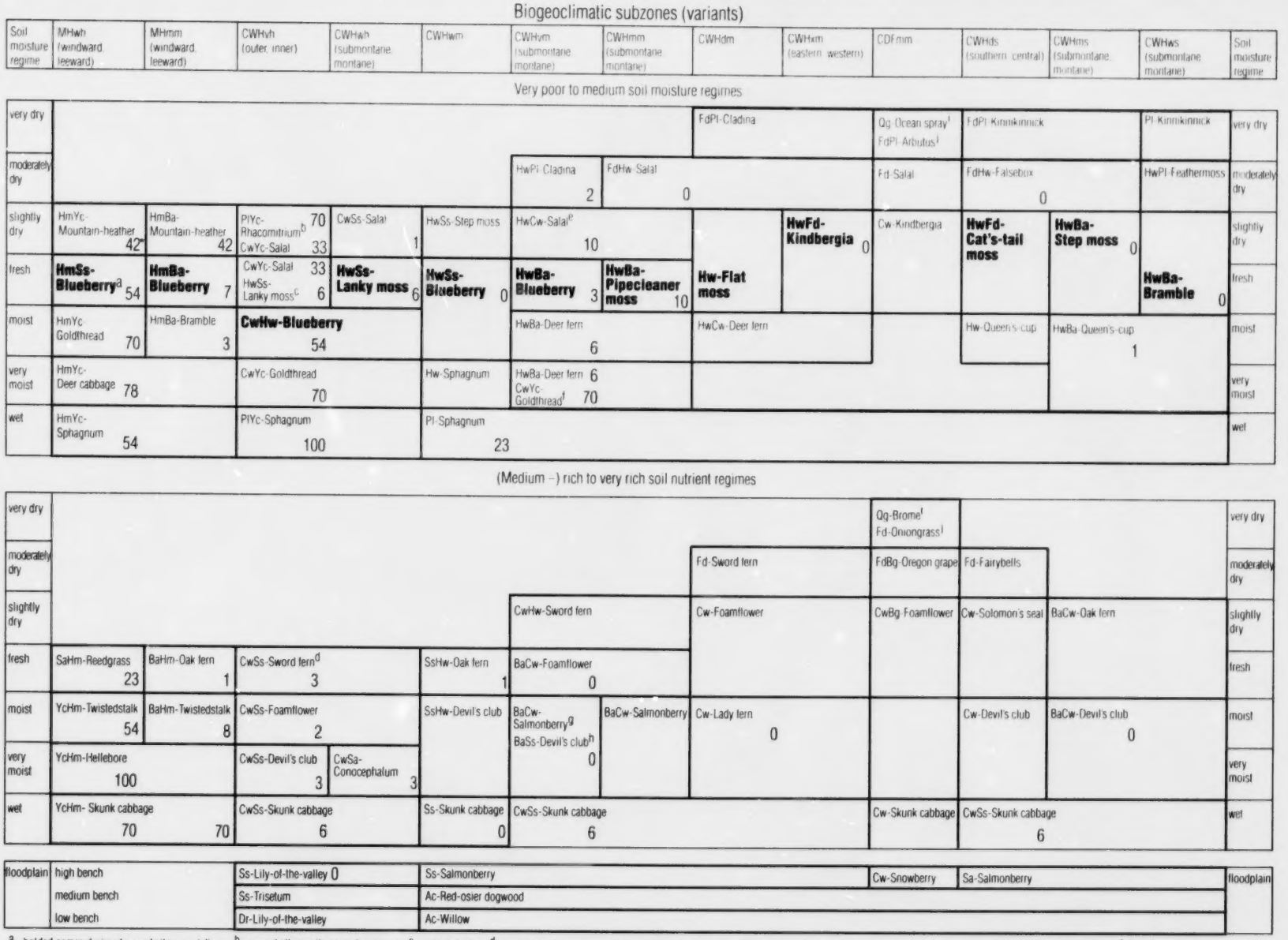
* A general description of biogeoclimatic units and ecosystem classification in British Columbia can be found in Meidinger, D.V., and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Min. For., Victoria, B.C.



[a] - bolded names designate zonal site associations; [b] - very shallow soils on rock outcrops; [c] - colluvial sites; [d] - sword fern is uncommon in the northern portion of the CWHvh subzone; [e] - salal is uncommon in the northern portion of the CWHvm subzone; [f] - in nutrient-very poor, depressions in the montane variants; [g] - in the southern portion of the CWHvm; [h] - in the northern portion of the subzone; [i] - in the southern (drier and warmer) portion of the subzone; [j] - in the northern (cooler and wetter) portion of the subzone.

* numbers refer to relative importance of yellow cedar based on natural occurrence

FIGURE 1. Site associations of coastal British Columbia.

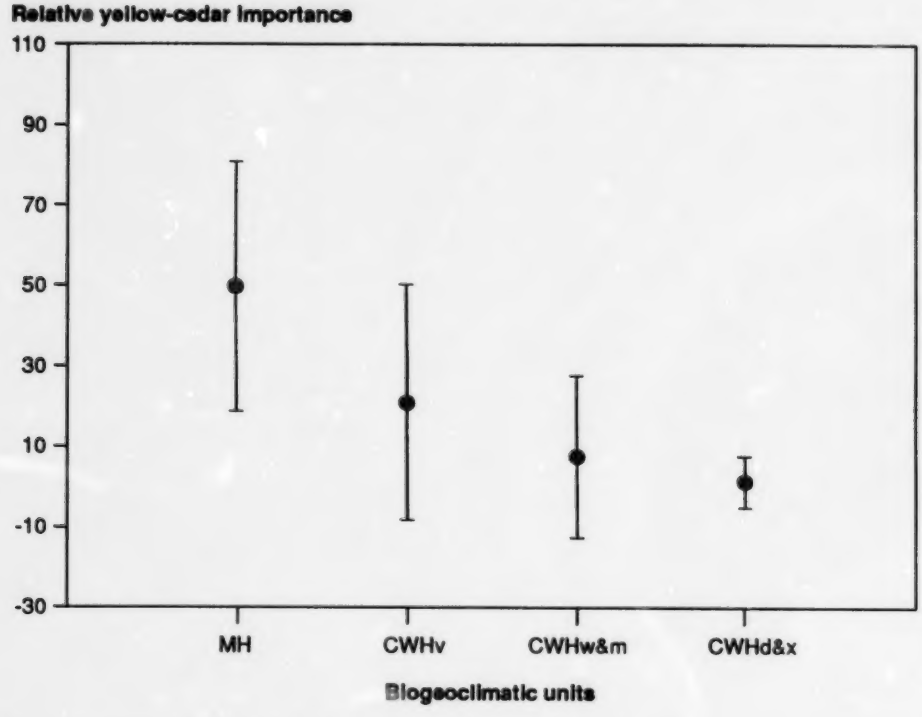


FIGURE 2. Occurrence of yellow-cedar in relation to regional climates.

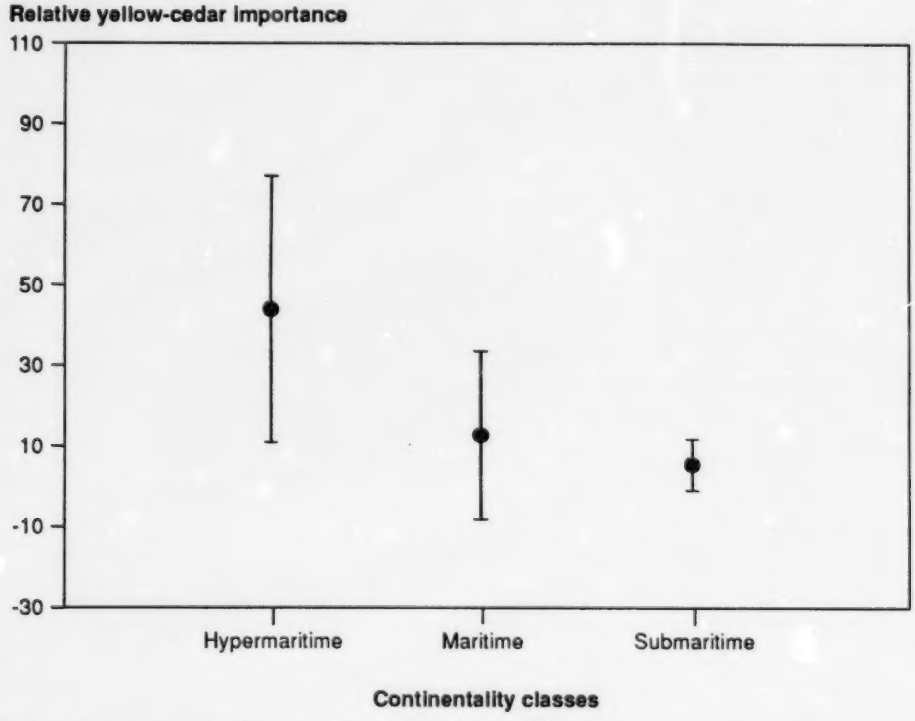


FIGURE 3. Occurrence of yellow-cedar in relation to continentality.

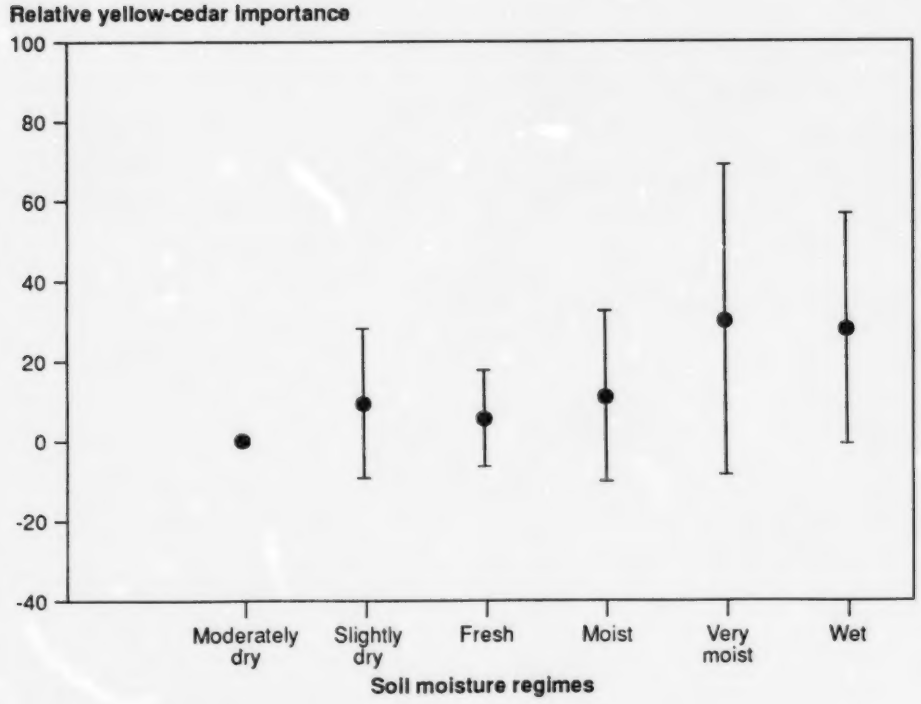


FIGURE 4. Occurrence of yellow-cedar along a soil moisture gradient.

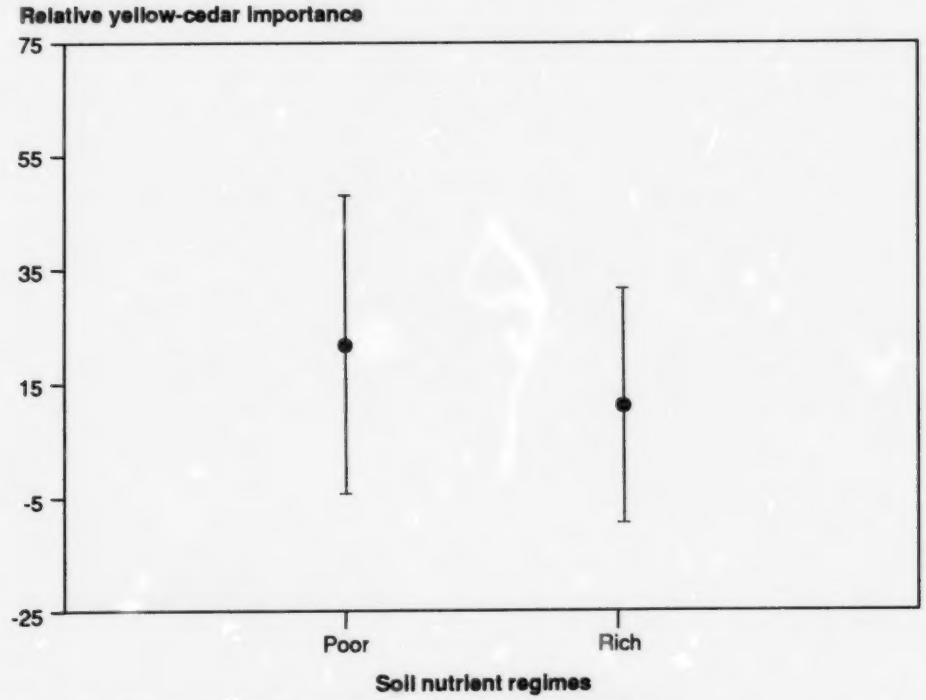


FIGURE 5. Occurrence of yellow-cedar along a soil nutrient gradient.

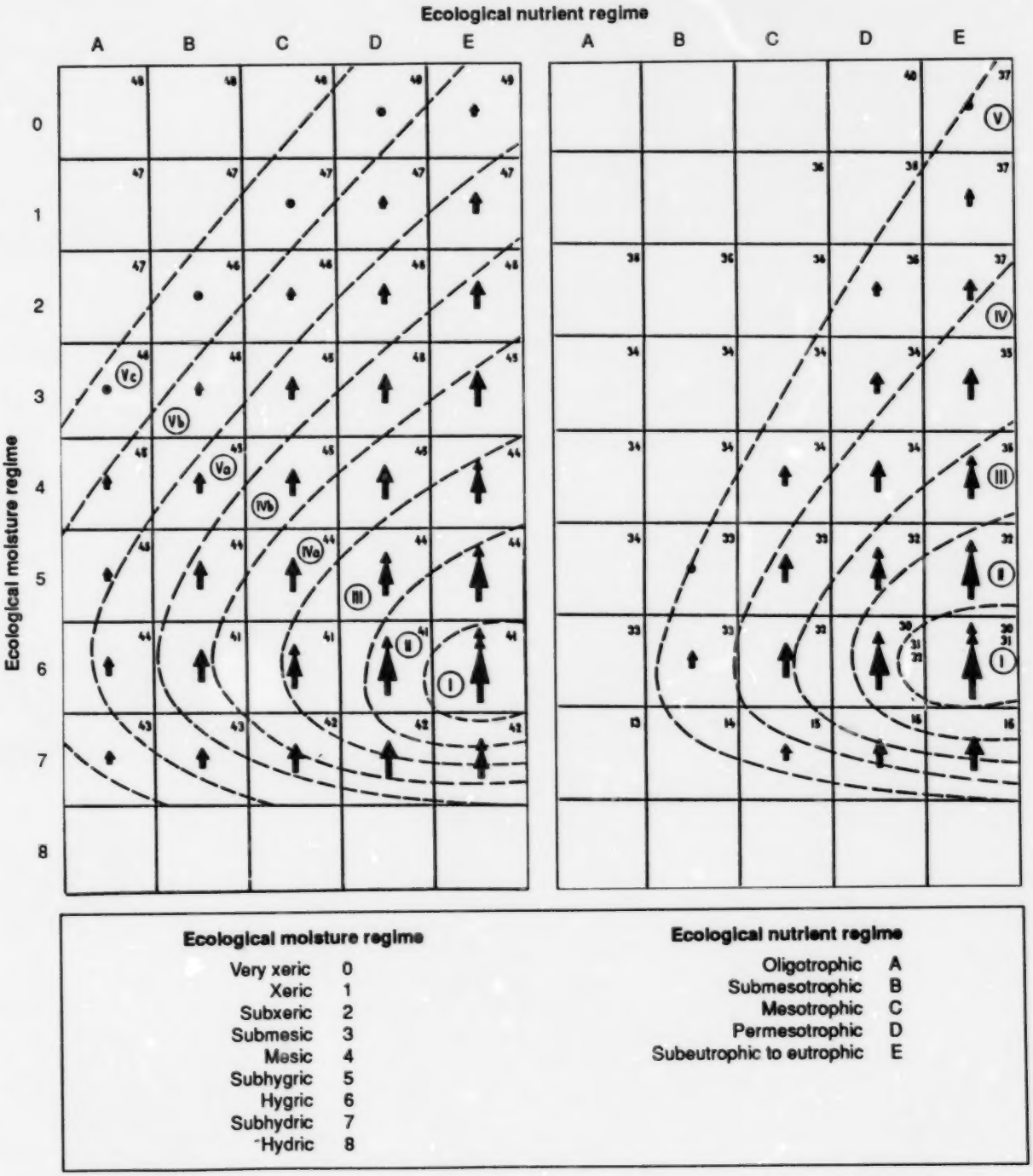


FIGURE 6. Ecological quality of yellow-cedar sites in the MH zone and wetter CWH subzones (from Krajina, 1969).

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Reproductive Biology: Pollen/Seed/Seed Orchards

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In its natural habitat in coastal British Columbia and southern Alaska, the reproductive cycle of yellow cypress extends over approximately 28 months from cone initiation until seed maturation. From pollination, cones and seed take 2 years to mature. Yellow cypress is not a heavy cone producer, but some seed are produced every year. The following report summarizes published and current information on pollen, seed and seed cone development in natural stands and seed orchards. These results are discussed in terms of the future regeneration of yellow cypress by seed.

Yellow cypress pollen cones develop on lateral branches, in the lower regions of the crown on shoots that have been vegetative for a least 1 or 2 years. Pollen cone initiation and development usually occur in late June or early July with the production of microsporophylls. The pollen cone is attached to the shoot by a short stalk. Each microsporophyll develops two or three microsporangia or pollen sacs. The pollen sacs form hundreds of large pollen mother cells. In late August, the pollen mother cells undergo meiosis, ultimately resulting in haploid microspores. The microspores develop into mature pollen grains by early September. The mature pollen grains enter winter dormancy and are not shed until the following April.

Pollen cone abortion during the fall and winter has been observed in yellow cypress clones at the Ministry of Forests, Cowichan Lake Research Station, and at Fletcher Challenge Canada's Mount Newton seed orchard on the Saanich Peninsula. The pollen cones are aborting because of the feeding habits of a mite, *Trisetacus chamaecypari*. From about September onward the mite feeds on the stalk of the pollen cone, eventually girdling the stalk and killing the pollen cone. Preliminary results indicate that about 30% of the 1989/1990 pollen cone crop at the Cowichan Lake Research Station and about 50–60% of the pollen crop at Mount Newton seed orchard were destroyed over the last winter as a result of the feeding habit of this mite. To date, no evidence of the mite has been found in natural stands of yellow cypress either at Mount Washington on Vancouver Island or Cypress Bowl in the Lower Mainland. The implications of this infestation to future cone crops have yet to be determined.

In natural stands, yellow cypress seed cones take 2 years to mature, resulting in immature 1-year-old cones and mature 2-year-old cones (Owens and Molder 1975). Pollination occurs in late to early April, fertilization in July, and embryos develop until early October and then go dormant. One-year-old cones are usually green and soft and can easily be opened with a fingernail. The seeds are immature and, if collected, would not germinate. Embryo development is completed the following spring and summer and the seeds are shed by September or October. Mature cones are yellow-green, often with dark brown resinous spots. They are hard and not easily opened with a fingernail. The seeds are dark brown with medium-brown wings, hard and dry. Because of the 2-year maturation cycle, immature 1-year-old cones and mature 2-year-old cones usually occur on the same branch, making cone collections more difficult and time consuming. Mature cones contain an average of one to three filled seeds per cone.

Recent findings from the Mount Newton seed orchard and the Canadian Pacific Forest Products (CPFP) seed production area (El-Kassaby 1990) located on the Saanich Peninsula suggest that at these warmer, drier sites, cone and seed maturation can occur in one growing season. It has been hypothesized that moving these trees from their high-elevation sites to a warm, dry low-elevation site provided suitable conditions for the seed cones to continue their development, without significantly slowing down their dormancy. In 1988, germination tests on seed extracted from 1-year-old cones from CPFP and Mount Newton seed orchards found between 8 and 42% germination at CPFP and between 7 and 64% germination from the Mount Newton seed.

Seasonal variation in the time required for seeds to mature is being observed at the Mount Newton seed orchard. In 1988, all clones had mature seeds in one season, while the 1989 cone crop will require two growing seasons. Meanwhile, only 3 km away at CPFP's seed production area, cone and seed maturation has been completed in one growing season, for 3 consecutive years. On-going studies are currently aimed at determining which factors affect seed maturation. Whether the seeds mature in 1 year or 2, seed production in the orchards is much higher than that observed in natural stands, averaging five to six filled seeds per cone.

In the fall of 1990, CPFP will outplant about 20 000 seedlings grown from seed extracted from 1-year-old cones.

Preliminary results suggest that the "deep dormancy" typically associated with yellow cypress seeds may be related to immaturity. Considerable variability in stage of embryo development at seed shed exists in all stands. Different stratification procedures are currently under review to determine their effect on maturation and germination. Future seed production in yellow cypress should take advantage of the reproductive plasticity and move seed orchards to warmer sites where seed production occurs in 1 year instead of 2. Yellow cypress would also be an ideal candidate for container orchards because of the ease with which it can be maintained in containers, its responsiveness to cone induction, and the ease with which cultural and environmental conditions can be manipulated. By using available biological information on the reproductive cycle of this species, future regeneration of yellow cypress from seed is a certainty.

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Physiological and Environmental Tolerances of Yellow Cypress

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INTRODUCTION

Yellow cypress is a tree species which grows in coastal Pacific Northwest forests. Forest regeneration programs in this geographical region are beginning to consider the use of yellow cypress as a larger component in their species allocation strategy. Information on a species' physiological response to reforestation site conditions is an important component in improving this decision-making strategy. Yellow cypress has been reported to be a shade-tolerant species requiring humid conditions, adequate soil moisture, and cool, but not low, temperatures for good growth (Fowells 1965). However, no previously reported information is available on the physiological response of yellow cypress to site environmental conditions.

GAS EXCHANGE RESPONSE TO ENVIRONMENTAL CONDITIONS

Planting yellow cypress seedlings on reforestation sites created by clearcut logging would expose them to environmental extremes. The most dramatic of these are alterations of heat exchange processes and site water relations which affect seedling water balance. Therefore, it is important to understand the interaction between physiological responses of yellow cypress to potential environmental conditions of a reforestation site.

Research has shown gas exchange processes to be primarily influenced by the atmospheric variables of light and evaporative demand under non-limiting edaphic conditions (Landsberg 1986). Reduced soil moisture and low soil temperatures can create physiological stress and reduce seedling establishment. Thus, the aboveground environmental variables of light and evaporative demand and belowground environmental variables of soil temperature and moisture can influence a plant's physiological response and subsequent establishment on a reforestation site.

Yellow cypress will open their stomata at light levels of around 5–10% of full sunlight. Net photosynthesis begins at these low light levels and continues to increase until it reaches near saturation between 25 and 33% of full sunlight. Further light level increases above 33% full sunlight result only in a slight increase in net photosynthesis. This gas exchange response is typical of most Pacific Northwest species.[1]

Both stomata and net photosynthetic processes of yellow cypress are very sensitive to increasing evaporative demand. Nearly a 50% decrease in stomatal conductance and net photosynthesis occurs as vapour pressure deficit increases from 1 to 2 kPa (i.e., equivalent to going from a very high to a moderate humidity level). Yellow cypress response to increasing evaporative demand is one of the more sensitive responses reported for Pacific Northwest species.[2]

Decreasing root temperatures from 22 to 1°C caused a rapid reduction in both stomatal opening and net photosynthesis, with both gas exchange processes ceasing at 1°C. This indicates a strong species

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1 Grossnickle, S.C. and J.H. Russell. 1991. Gas exchange processes of yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) in response to environmental variables. Can. J. Bot. 69:2684-2691

2 Ibid.

sensitivity to decreasing root temperatures from 22 to 1°C. This temperature sensitivity is greater than that for most other reported Pacific Northwest species.[3]

Decreasing pre-dawn shoot water potential resulted in a rapid reduction in stomatal opening and a gradual decline in net photosynthesis. Rapid stomatal closure in yellow cypress with greater plant moisture stress indicates a strong sensitivity to drought. This gas exchange response is comparable to that for other reported Pacific Northwest species.[4]

SEASONAL PHYSIOLOGICAL PATTERNS

Seasonal changes of physiological resistance to normal environmental patterns needs to be considered if yellow cypress is to be successfully planted on reforestation sites. These seasonal environmental patterns will be more extreme on cutover sites. Thus, an awareness of a species' seasonal physiological limitations is required.

Drought Tolerance

Yellow cypress drought tolerance capability shifts seasonally and corresponds to shoot growth patterns. Drought tolerance is at a yearly low during the late spring and early summer when the shoot system is elongating. Drought tolerance increases during the fall and is at a maximum during mid-winter. This seasonality in drought tolerance is typical of most species (Abrams 1988).

Frost Hardiness

Frost hardiness increases rapidly during the fall and reaches a maximum LT_{50} of -20°C around January 1. This increase in frost hardiness is caused by decreasing light levels and increasing hours of frost events (i.e., up to 130 <0°C degree hours). This level of seasonal frost resistance is within the range reported for other *Chamaecyparis* species (Saki 1983). Beyond January 1, continued increases in hours of frost events do not cause any further increases in frost hardiness. Thus, increasing light levels, in mid- to late winter, may prevent greater yellow cypress frost hardiness.

CONCLUSION

This paper briefly examines the physiological response characteristics of yellow cypress to environmental conditions that can occur on reforestation sites. Physiological data confirm the general species/site ecological explanation of Fowells (1965): that yellow cypress is shade tolerant, and that it requires humid conditions, adequate soil moisture, and cool but not low temperatures for good growth. Physiological capabilities and limitations of yellow cypress need to be considered when forest regeneration programs are formulated for the Pacific Northwest.

ACKNOWLEDGEMENT

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3 Grossnickle, S.C. and J.H. Russell. 1991.
4 Ibid.

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The Genetics of Yellow Cypress

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Genetic studies concerning yellow cypress have been limited in the past. Results from more recent trials, however, have shown a wealth of genetic variability in biochemical, phenological, physiological, and morphological traits at the provenance, family, and clonal level. These encouraging results have prompted the development of a genetic improvement program.

GENETIC ARCHITECTURE

Yellow cypress is one of eight species in the *Chamaecyparis* genus. Hybrids between yellow cypress and several of the Asian species have been reported (Zobel *et al.* 1985). On the other hand, natural hybrids between yellow cypress and Port Orford cedar, where the ranges of the two species overlap, are rare. Hybrids between yellow cypress and Monterey cypress (*Cupressus macrocarpa*) are easily obtained, occurring naturally in arboreta where the two species have been planted together.

Phenological studies of yellow cypress in seed orchards have shown abundant clonal variation (T. Crowder, unpubl. data, Fletcher Challenge). As well, there is variability in flowering response to gibberellin (GA_3) (Bower *et al.* 1989), and seed cone abortion (A. Colangeli, unpubl. data, Univ. of Victoria). Preliminary biochemical investigations using terpenes (E. Von Rudloff, unpubl. data) and isoenzymes (D. Delany, unpubl. data, U.S. Dep. Agric. For. Serv.) have also indicated considerable tree-to-tree variation.

Early results from genetic architecture studies, involving a range-wide provenance collection with open-pollinated families, have shown significant but minimal provenance variability, and large family and clonal variation in morphological traits (Tables 1 and 2). Narrow-sense heritabilities for first-year seedling growth traits were high (Table 1). Broad-sense and narrow-sense heritabilities for third-year height in a clonal field trial were also high (Table 2). Most of the variation in third-year height was attributed to additive gene effects. These results agree with those of Akasi and Kawamura (1977) who studied the same traits with hinoki (*Chamaecyparis obtusa*) using full-sib families. Significant provenance variation in frost hardiness, using 1-year-old seedlings, correlated weakly with latitude. Southern populations were the most frost-susceptible (J. Russell, unpubl. data).

TABLE 1. Percent of total variability and narrow-sense heritabilities (H^2) for first-year growth traits of yellow cypress in a genetic architecture study

	Variability (%)			
Measurement	**Provenance**	**Family**	**Error**	**H^2**
1-year height	2	24	74	0.73
1-year diameter	0	11	89	0.33
Root weight	4	11	85	0.34
Root/Shoot ratio	11	19	70	0.65

TABLE 2. Percent of total variability and heritabilities for early height of yellow cypress in a clonal trial

	Variability (%)				Heritability	
Measurement	Prov.	Family	Clone	Error	Broad	Narrow
1-year height	5	3	53	38	0.10	0.84
3-year height	0	21	40	39	0.63	0.82

These early tests give encouraging evidence of exploitable variability, but verification by longer-term testing, as well as assessments of other important commercial traits such as wood quality, is essential.

GENETIC IMPROVEMENT

The genetic improvement of yellow cypress involves a two-thrusted approach: provenance testing with family structure, and a breeding program involving recurrent selection for additive gene effects.

Provenance Testing: The objectives of the provenance program are to: 1) develop seed transfer guidelines; 2) determine the extent and pattern of genetic variability; and 3) maintain an *in situ* gene pool. Seed from over 50 provenances and 300 open-pollinated families have been collected and testing has commenced. Testing involves two strategies: one, short-term testing for genetic variability in early growth and adaptability in the greenhouse and nursery beds and, two, long-term field trials.

Breeding Program: The objective of the breeding program is to improve commercial traits of yellow cypress through breeding, testing and selection, while maintaining acceptable levels of adaptability. Initially, over 250 parent trees were selected in the wild and cloned into production seed orchards and a breeding orchard. Since this was before any planned breeding program, no open-pollinated seed was collected. Breeding among the selected parent trees to produce full-sib families for testing, and ultimately to select for both an advanced generation population and production population, has now begun with eight-clone circular disconnected partial diallels. Progeny trials will be established with the use of clonal replicates. Thus, two production options will be available for the deployment of genetically improved material: seed orchards containing clones selected according to their general combining ability; and superior clones selected from the cloned progeny and trials.

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Diseases, Insects, and Animal Damage of Yellow Cypress

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Have you ever wondered why yellow cypress heartwood smells so good? Or why its foliage, when crushed in your hands, has that wonderful aroma? Yellow cypress has the ability to live as long as nearly any tree species in the world — up to several thousand years. For a tree to live so long, it must have exceptional defences against its natural enemies. The natural enemies of most coniferous trees are fungi and insects, and sometimes animals. The reason that heartwood, foliage, and other parts of yellow cypress have such distinctive smells is that they are loaded with defensive compounds (Barton 1976) which limit the attack and growth of pests (Rennerfelt and Nacht 1955). What smells good to us is lethal to many insect and fungal pests. Thus, yellow cypress has few natural enemies and is undamaged by most organisms that attack other conifers.

This is not to say that yellow cypress does not have natural enemies or that forest managers will not be faced with diseases, insects, or animals which will limit its productivity and yield. Some organisms have evolved the specialized skills of overcoming these chemical defences. Others attack tissues, such as phloem or dead sapwood, which lack concentrations of defensive chemicals. In this paper, I will discuss our current state of knowledge of pests of yellow cypress.

INSECTS

Compared with other conifers, yellow cypress has few insect pests. The most common damaging insect pests, bark beetles in the genus *Phloeosinus*, are not aggressive and typically attack trees that are already dying or recently dead. These beetles feed on the inner bark (phloem) of the boles or branches where they produce galleries typical of the bark beetles which attack pines and other conifers. Several species of *Phloeosinus* occur in different portions of the natural range of yellow cypress, but the behaviour of the insect species is fairly constant. The attack of *P. cupressi* in southeast Alaska is typical; yellow cypress trees are infested only after their crowns show symptoms of some previous stress, such as the syndrome known as cypress decline or cedar decline (see discussion on decline below). Likewise, the roundheaded borer *Atimia hoppingi*, commonly bores large galleries in the wood of dead trees, but does not harm live trees.

The cypress tip moth (*Argyresthia* spp.) and cypress leaf tier (*Epinotia subviridis*) sometimes cause damage by feeding on foliage of species of cypress, cedar, and juniper, but they are uncommon or non-damaging on yellow cypress (Furniss and Carolin 1977; Duncan 1983).

Little is known about insects which invade cones and kill seeds of yellow cypress. With a 2-year maturation phase, the cones may be susceptible to this form of damage. Several species of *Laspeyresia*, *Argyreshia*, and *Ernobius* (Hedlin *et al.* 1981) damage seeds of species of *Chamaecyparis* and *Cupressus*, but their incidence on yellow cypress has not been studied. The current emphasis on vegetative reproduction for producing regeneration stock may limit the impact of these insects, which might otherwise cause damage in seed orchards.

DISEASES

Two shoot blight fungi cause the most damaging regeneration diseases of yellow cypress. The first, caused by the fungus, *Kabatina thujae*, is a serious disease of yellow cypress in nurseries of British

Columbia. In 1969, a notable outbreak occurred in the Fraser River area (Funk and Molnar 1972) where up to one-half of the shoots of many trees were killed. Older woody tissue was not affected. The fungus was so persistent that spraying fungicides was ineffective and many trees were destroyed (Funk 1974). This fungus is also known from Europe where it infects ornamental yellow cypress and its close relatives. It may have originated in Europe and then been introduced into British Columbia, but its origin is uncertain. This fungus is apparently not a threat to seedlings, saplings, or trees in forested environments.

The second damaging shoot blight is very common in coastal Alaska. It is caused by an undescribed fungal species in the genus *Apostrasseria*. In spring, the fungus kills lateral shoots or terminal shoots of regenerating seedlings or saplings. The sexual stage of the fungus has not been found, but it likely belongs to the genus *Phacidium*, a group of fungi that infect conifer tissues under snow. Although dead shoots are common on small trees that may have been under snow during winter, I have also found shoots dying above the highest snowpack. Research is needed to determine the life cycle of the fungus and to demonstrate conclusively its pathogenicity.

In an extensive survey of fungi on yellow cypress (Hennon 1990), *Apostrasseria* was never encountered on mature trees. The disease is very common in young trees that naturally regenerate in clearcuts. Based on some preliminary data of a regeneration study in Alaska, the disease appears to be common on planted seedlings. *Apostrasseria* will probably not cause mortality of infected seedlings or saplings unless they are heavily colonized. The effect on growth or form, if terminal shoots are killed once or repeatedly, is not known. The fungus has not been reported outside Alaska. Unlike *Kabatina thujae*, this fungus does not cause disease in nurseries.

Two fungi, *Herpotrichia juniperi* and a small yellow disc-shaped fungus, *Gelatinodiscus flavidus* (Carpenter 1976), can colonize and kill foliage or twigs of yellow cypress under snow. Neither is probably a threat to regeneration. The most serious shoot blight and canker disease of *Chamaecyparis* species worldwide is caused by *Seiridium cardinale* (Strouts 1972). This fungus has not been reported causing disease on yellow cypress within the natural range of this tree. I found the fungus once in Alaska, where it was isolated from an old scar on a yellow cypress tree, but the fungus was of a non-pathogenic form that did not harm seedlings when inoculated. If introduced, a pathogenic form could be very damaging to managed and unmanaged stands.

A rust fungus causes a common, although non-damaging, disease throughout the natural range of yellow cypress. The rust species *Gymnosporangium nootkatense* causes small orange pustules on infected foliage scales. Typically, only one or two foliage scales are affected. Twig swelling has been reported (Ziller 1974), but this is a rare symptom that I have never observed. As with many rust fungi, the fungus attacks an alternate host as part of its life cycle, in this case the leaves of Pacific crabapple and mountain ash. Even though this rust disease is very common on yellow cypress, disease levels within trees are so light that the fungus probably has no measurable effect on growth or yield.

In Alaska, a minor branch disease is common in mature trees. Small swellings with roughened outer bark are caused by an undescribed fungal species of *Dermea*. Swellings do not enlarge appreciably and inner bark tissues (phloem) are not killed. Thus, the disease probably has little effect on tree health or growth.

Several fungi which are common in nurseries attack yellow cypress seedlings. *Botrytis cinera* is probably the most common. Damping-off fungi that kill emerging seedlings are also common. Soil pasteurization or chemical measures are effective in controlling these diseases. A number of root disease fungi are reported on yellow cypress, but few are considered to cause serious disease. *Armillaria* spp. can cause destructive root disease to conifers, but the species of *Armillaria* common on yellow cypress are fairly benign. They attack and kill trees already dying of other causes. For example, *Armillaria* is common on trees dying from decline (see discussion on decline below), but seems to lack the ability to kill healthy trees in Alaska.

Heterobasidion (Fomes) annosum is another fungus that causes serious root disease and butt rot in other conifers. Although it is common on other conifers throughout the Pacific coast, it is apparently rare

on yellow cypress. It has been found only once on yellow cypress — on a downed log — in Alaska (Hennon 1990).

Phellinus weirii is probably the most serious root disease of conifers in western North America. The taxonomy of this fungus is currently being studied. The form that occurs on yellow cypress causes a significant cull as a butt rot, but does not incite root disease or direct mortality. Because yellow cypress is very resistant to the form of *P. weirii* that causes root disease, it may be a good choice to plant on managed sites infested with this root disease. The most serious root disease to trees in the genus *Chamaecyparis* is caused by the fungus *Phytophthora lateralis*. On Port Orford cedar, the fungus is so virulent that large trees can be killed in a year or two. Since its introduction to the Northwest from unknown origins, the fungus has spread to northern California and British Columbia.

No Port Orford cedar known, whether growing in the forest or planted as an ornamental, is thought to have genetic resistance to the fungus. Ornamental yellow cypress trees sometimes die from the disease, but this species is apparently somewhat more resistant to the fungus than Port Orford cedar. In extensive sampling, we could not recover the fungus from yellow cypress forests in coastal Alaska (Hansen *et al.* 1988). *Phytophthora lateralis* has not been reported in yellow cypress forests in British Columbia, Washington, or Oregon. To date, therefore, the fungus has not invaded commercially important natural stands or plantations.

DECAYS

A number of fungi are known to cause internal wood decay in live yellow cypress, but quantifying the amount of loss by each of the fungi has not been conducted. Most of the Basidiomycetes listed in Table 1 cause decay in yellow cypress; however, most are saprophytic on wood of dead trees. Numerous species are unspecialized and attack the sapwood of dead yellow cypress because it does not contain concentrated chemical defences. The only common conk-forming fungus that I have found on yellow cypress in Alaska is *Polyporus elegans* (Hennon 1990) which is abundant on sapwood of recently killed trees.

A form of *Phellinus weirii* causes much of the butt rot in old yellow cypress trees in unmanaged stands. *Oligoporus serceomollis* is also known to cause heartrot in old-growth yellow cypress stands, but which organisms are the most important, and at what age in yellow cypress they begin to cause substantial decay, are unknown.

The heartwood of yellow cypress is sometimes stained by a black or dark colour. Smith (1970) isolated fungi from these stains, which seemed to develop around knots, but did not identify the fungal species. The staining fungi do not affect the strength of infected wood, but they appear to detoxify the defensive chemicals in heartwood and thereby allow other fungi to initiate decay (Smith and Cserjesi 1970). The wood of yellow cypress is well known for its decay resistance and durability. When exposed to moisture, especially in the presence of soil, a number of organisms can cause decay. Unlike the heartwood's concentration of defensive chemicals, the sapwood is unprotected when dead and decays as quickly as wood of tree species without decay resistance.

ANIMAL DAMAGE

Brown bears (*Ursus arctos*) strip the bark from the lower bole of cypress every spring in coastal Alaska (Hennon 1987; Hennon *et al.* 1990). An average of 49% of yellow cypress trees had bole scars in unmanaged stands on Chichagof and Baranof islands surveyed in Coastal Alaska. Wounding incidence was greatest on well-drained productive sites where yellow cypress trees reach their greatest dimension and value. Scars were either old and callusing or recently produced, with teeth marks still showing in exposed wood. Trees with old wounds have an associated decay column in the butt log. Trees of other

species are not affected. Yellow cypress growing on islands inhabited by black bears and not brown bears do not have this form of wounding.

TABLE 1. Fungi on yellow cypress

ASCOMYCETES

Asterina cupressina Cke.
Bertia moriformis (Tode: Fr.) de Notaris.
Ceratocystis sp.
Chloroscypha seaveri Seaver
Cyanodiscus occidentalis E. Muller & M.L. Farr
Dermea sp.
Dothidea sp.
Gelatinodiscus flavidus Kanouse & A.H. Smith
Gnomoniella sp.
Eriosphaeria vermicularis (Nees: Fr.) Sacc.
Herpotrichia juniperi (Duby) Petr.
Nectria sp.
Pezicula sp.
Pithya cupressina (Fr.) Fckl.
Pleospora laricina Rehm
Scutellinia scutellata (L. ex St. Amans) Lambotte
Seynesiella juniperi (Desm.) Arn.
Stictis radiata (L.) Pers. subsp. radiata
Tryblidaria washingtonensis Kanouse
Venturia lanea Deam.

BASIDIOMYCETES

Aleurodiscus weirii Burt
Antrodia xantha (Fr.) Ryv.
Armillaria sp.
Auricularia auricula (Hooke.) Underw.
Botryobasidium obtusisporum John Erikss.
Cyathus olla Batsch ex Pers.
Dacrymyces deliquescens (Merat) Duby. subsp. *deliquescens*
Dacryobolus karstenii (Bres.) Oberw. & Parm
Diplomitoporus lenis (Karst.) Gilbn. & Ryv.
Fomitopsis pinicola (Swartz: Fr.) Karst.
Galerina sp.
Gloeophyllum sepiarium (Wulf.: Fr.) Karst.
Gymnosporangium nootkatense Arth.
Heterobasidion annosum (Fr.) Bref.
Hyphodontia aspera (Fr.) J. Erikss.
Hyphodontia pallidula (Bres.) J. Erikss.
Hyphodontia subalutacea (Karst.) J. Erikss.
Jaapia argillacea Bres.
Lactarius deliciosus (Fr.) S.F. Gray
Lycoperdon sp.
Naematoloma dispersum (Fr.) Karst.
Nidularia sp.
Oligoporus sericeomollis (Rom.) Pouz.
Phaneochaete sanguinea (Fr.) Pouz.
Phellinus pini (Thore: Fr.) Pilat.
Phellinus weirii (Murr.) Gilbertson
Pistillaria sp.
Polyporus elegans Bull.: Fr.
Pseudohydnum gelatinosum (Fr.) Karst.
Serpula himantioides (Fr.) Bond.
Skeletocutis amorpha (Fr.) Kotl. et Pouz.
Tubulicrinus regificus (Jacks. & Deard.) Donk
Xeromphalina campanella (Batsch.: Fr.) Kuhn. & Maire.

OOMYCETES

Phytophthora lateralis Tucker & J.A. Milbrath

IMPERFECTS

Apostrasseria sp.
Aureobasidium pullans (de Bary) Arn.
Botrytis cinerea Pers.
Coryneum berckmanii Milb.
Cryptosporiopsis sp.
Cylindrocarpon didymum (Hart.) Wollenw.
Cytospora abietis Sacc.
Dictyosporium elegans Corda
Ditangium sp.
Engelhardtiella alba Funk
Gibbera sp.
Gliocladium sp.
Kabatina thujae Schneid. & Arx
Kirchsteiniella thujina (Peck) Pomerl. & Ether.
Leptographium sp.
Pestalotia thujae Sawada
Pestalotiopsis funerea (Desm.) Stey.
Phialophora melinii (Nannf.) Conant
Phoma sp.
Phomopsis juniperovora Hahn
Seiridium cardinale (Wagener) Sutton & Gibson
Septonema secedens Corda
Spegazzinia tricholophila Atk.
Sporidesmium sp.
Verticillium sp.

MYCELIA STERILIA

Mycelium radicis atrovirens Melin

Porcupines are known to damage a variety of trees species (e.g., Sitka spruce, western hemlock) that grow in managed stands with yellow cypress in coastal British Columbia and coastal Alaska. Yellow cypress may not be a preferred food for porcupines and may be a good species to manage in coastal areas where porcupine damage is known to be severe.

Deer browsing is a problem in some regenerating stands of yellow cypress. Preliminary results of a regeneration study that I am conducting in southeast Alaska suggest that deer feed on yellow cypress foliage that is 1 or 2 years old. Seedlings that are browsed several years in a row become bushy and have increased radial stem growth. It appears that, if unbrowsed for 1 or 2 years, they will grow rapidly in height and be too tall to be significantly damaged further by deer. Although browsing is common, deer do not typically cause damage in the same stand year after year. Direct damage by deer may be more chronic in areas such as the Queen Charlotte Islands where deer are very plentiful. A damaging effect of deer browsing may be that it makes regenerating yellow cypress less competitive against fast-growing hemlock and brush species.

DECLINE AND MORTALITY

The most serious mortality problem of yellow cypress is referred to as cedar decline or cypress decline. It occurs on over 200 000 hectares of unmanaged forest distributed throughout southeast Alaska (Fig. 1). Its distribution in British Columbia is not well documented, but decline in the province is likely either less common or less severe. In Alaska, decline is common on sites with poor moisture drainage (Hennon *et al.* 1990b). Other tree species on these sites are significantly less affected. In nearly a decade of research on the problem, we have determined that the extensive mortality began throughout southeast Alaska, more or less simultaneously, in about 1880 (Hennon *et al.* 1990c). Many of the trees killed over 100 years ago are still standing.

Since onset of the problem, trees have continued to die on sites of decline. The problem has encroached about 100 metres into adjacent stands, but mortality has not appeared on any new sites (Hennon *et al.* 1990b). Thus, decline apparently is not contagious. Symptoms of dying trees suggest that a root pathogen may be responsible for death (Hennon *et al.* 1984, 1990d). Over 50 fungi were isolated or collected from yellow cypress trees, but none had the capability of killing healthy trees or seedlings (Hennon 1990; Hennon *et al.* 1990d). Insects and nematodes (Hennon *et al.* 1985) have been investigated, and they, too, are not the primary cause of decline.

It now appears as though no biotic agent causes decline. Although the cause is still a mystery, we are confident that the problem is related to the wet, exposed sites where decline occurs and that the problem will not spread to our managed stands. Ongoing research examines possible abiotic causes of decline (e.g., freezing, desiccation, soil toxicity) and possible associations of climate change.

An important message for forest managers is that decline is not caused by a contagious agent and will not spread to sites where it is not already present. Decline occurs on wet, poorly drained sites, primarily in Alaska. Thus, managers can confidently manage yellow cypress on good sites without fear of the decline problem.

There is still much to learn about diseases and insects of yellow cypress both in unmanaged forests and in plantations. Undoubtedly, pests not mentioned in this discussion will emerge as important factors in the management of this valuable forest species. As we learn more, perhaps we could discuss those pests at our next yellow cypress symposium.

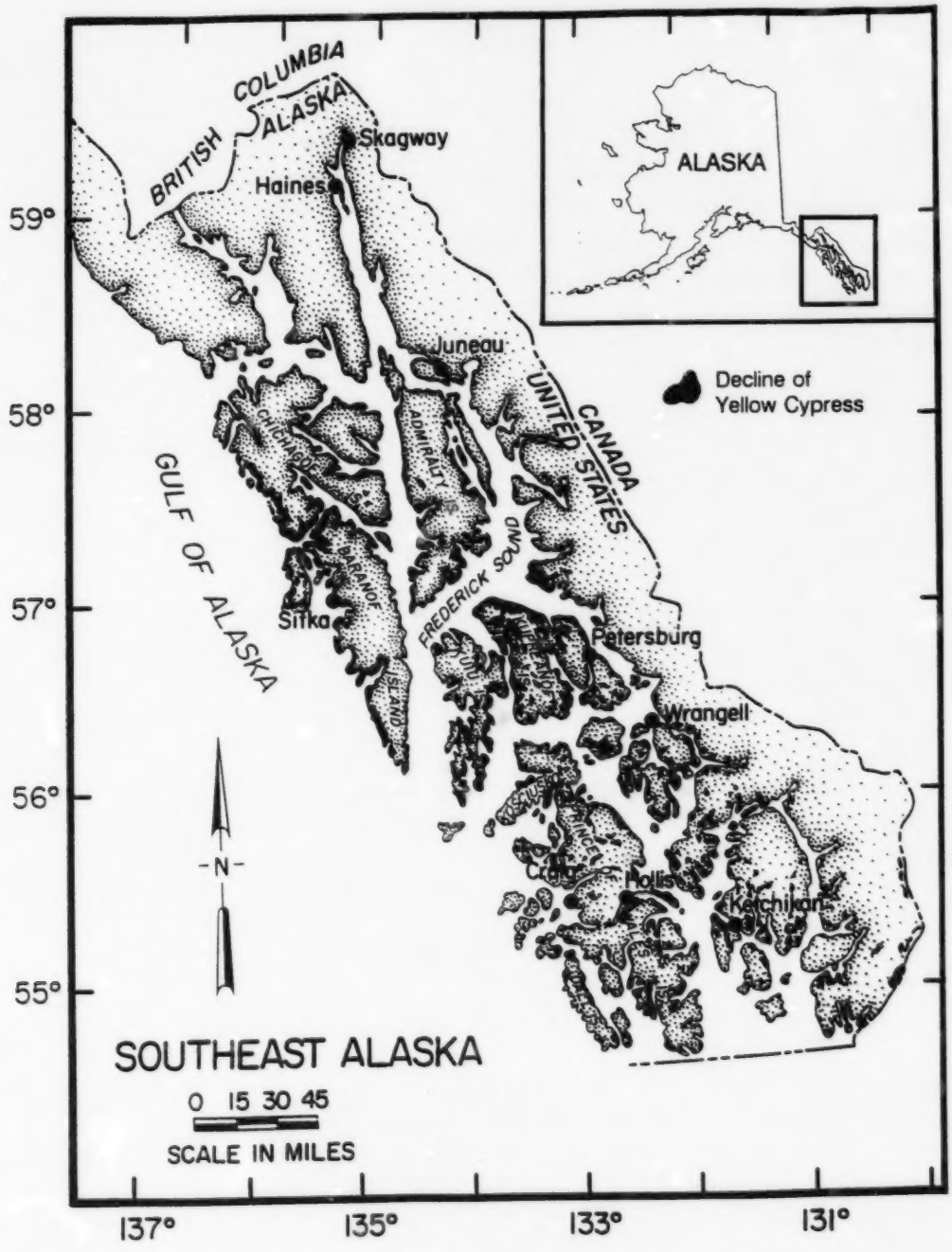

FIGURE 1. General distribution of decline and mortality of yellow cypress in southeast Alaska.

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Operational Use of Yellow Cypress in Coastal British Columbia

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The pattern of harvesting in British Columbia has been a progression from lower to higher elevation sites, especially in southern B.C. Yellow cypress, while it occurs throughout the range of latitude in the province, is restricted to higher elevations in the south, reaching sea level towards the northern end of Vancouver Island. As the area cut in yellow cypress types has been increasing fairly rapidly, it is not surprising that the interest in regenerating the species has been rising.

Plantation efforts in the species began in the early 1970's when the Mission Tree Farm undertook planting of cutover sites above about 600 m elevation. These plantings amounted to about 20 000 seedlings per year at elevations above about 700 m. Beginning in the mid-1980's, other organizations began planting yellow cypress so that by 1987, sowing requests were 571 000 and by 1990, 868 000.

Concurrently with these early plantation efforts, a research program investigating vegetative propagation was begun by Ingemar Karlsson at Cowichan Lake which, during the 1970's, laid the basis for an alternative approach to producing planting stock. Also, high-elevation species planting trials which included yellow cypress were begun by Mike Arnott and Helmar Hahn. Progress in industrial plantations of yellow cypress has relied heavily on this early work.

The purpose of this presentation is to summarize operational plantation efforts and outline some of the current thoughts on where we are going.

PLANTING EXPERIENCE

The Mission Tree Farm plantations were established as hot-planted 2-0 stock in PSB 415 containers at 2.7 m spacing in the CWHvm2 variant and MH subzones. Because stands established on slashburned sites have experienced butt sweep problems associated with snow creep and the heavy lower branching habit of cypress, slashburning is now avoided on steeper sites. Survival has been high (>90%) on all but the harshest sites. Some problems encountered with poor form and multiple leaders appear to be lessening, as apical dominance is not becoming more strongly established.

MacMillan Bloedel established its first cypress plantation at Stillwater in 1975 with stock acquired from the Mission Tree Farm Licence. Larger operational plantings began about 1982 with stecklings and seedlings. By 1989 they had reached about 280 000 per year. Virtually all stock is PSB 313 1-0. Survival has been excellent on most sites and, while early growth is slow, by age three trees are usually growing well. Currently sites that are being planted are in the following ecological variants* (old codes are in parentheses):

CWHvm1 (CWHb1):	higher elevations and warmer aspects in areas unfavourable for Douglas-fir. Site # 3, 4 & 5.
CWHvm2 (CWHb2):	warmer aspects. Site # 3, 4, 5 & 6.
CWHmm1 (CWHb3):	upper elevations on aspects too cool for Douglas-fir. Site # 5.5, 6, 7, 8.
CWHmm2 (CWHb4):	warmer aspects Site # 4.5, 5, 6 & 7.

* Described in Green, R.N., P.J. Courtin, K. Klinka, R.J. Slaco, and C.A. Ray. 1984. Site diagnosis, tree species selection, and slashburning guidelines for the Vancouver Forest Region. B.C. Min. For., Victoria, B.C.

Fletcher Challenge currently plants only minor amounts (up to 10 000 per year) of yellow cypress on wetter sites in the CWHmm2. On better drained sites, Engelmann spruce is preferred.

Canadian Pacific Forest Products is currently planting about 25 000–30 000 yellow cypress per year. These are distributed through several biogeographical variants. Approximately 10 000 go into the CWHms1 near Whistler and on the east side of Harrison Lake. Another 10 000 are planted at higher elevations near Cowichan in the MH and CWHmm2. The remaining 10 000 are planted in the CWHvm1 and vm2 near Gold River at elevations at or above 600 m. Some plantations have also been established near Estevan in the CWHvh1. These have been heavily impacted by wind but probably no worse than other species. Survival has been generally good. Slashburning is avoided because it appears to be associated with stem malformation and butt sweep.

The Greater Vancouver Regional District also plants about 20 000–25 000 yellow cypress per year on cool, moist high-elevation sites in the MH and CWHmm1 variant, with the aim of maintaining a diverse species mix that resembles the original stands present before harvest.

Western Forest Products first established a planting trial of yellow cypress on a good site near Victoria Lake in 1979. Between about 1986 and 1989, planting increased to 205 000. Initially, planting was limited to the higher elevations (600 m+) in the CWHmm1 variant and MH subzones. However, there is currently an increased interest in planting yellow cypress on sites where hemlock and amabilis fir are experiencing nutrient stress. Such sites occur both in the montane, often associated with very dense *Vaccinium*, and in the CWHvm1 on Cedar/Salal sites.

Stock used has generally been PSB 313 1-0 with about a 50/50 mix of stecklings and seedlings. Survival has been high, generally above 90%, with acceptable to good growth depending on site and elevation.

GROWTH AND DEVELOPMENT

Growth of yellow cypress is generally thought to be slow, possibly because of its association with poorer, high-elevation conditions. The Permanent Sample Plots growth and yield data base for British Columbia has very few plots for the species to either support or reject this claim. The few that do exist suggest that for mesic sites, an MAI of about 7–8 m^3/ha can be expected on sites that are in the range of site index 17–23 m at 50 years BH age.

Early performance of cypress on nutrient-poor sites is encouraging. On northern Vancouver Island, yellow cypress and western redcedar are performing comparably in two Western Forest Products trials and appear to be outgrowing hemlock on these poorer sites (Fig. 1). On better sites, cypress appears to be doing well but is not capable of growth rates that will allow it to compete with Douglas-fir and hemlock (Fig. 2), suggesting that it does not occur on better low-elevation sites because of competition rather than other site factors. MacMillan Bloedel has also established five trials comparing the growth of redcedar and yellow cypress over a range of elevations between 50 and 1500 metres.

The value of cypress makes expansion of the species to a wider range of sites attractive, providing the effort can be shown to be biologically possible and that a sufficient quantity of planting stock becomes available. Currently there is uncertainty that this can be accomplished with seedlings.

Clonal propagation has proved to be successful and provides a substantial fraction of the planting stock currently available. What is lacking is a definition of genetic transferability that is based on testing. Little is known about genetic variation in the species. However, it is evident that there is much variability in the species.

The relationship between value and quality is very high, which means that efforts in tree improvement will pay large dividends. The use of clonal selection offers a very efficient means of capturing such genetic values, provided maturation effects are unimportant.

Western Forest Products (in addition to the Forest Service) has a large clonal hedge in place and is currently undertaking an evaluation of the patterns of genetic variability in it, in relation to seedlot, clone, elevation and latitude on a range of sites. Current studies suggest that there is a significant amount of genetic variation between clones (Figs. 3 and 4), but the experiments are not old enough to be free from propagation effects. Studies carried out at Cowichan Lake Forest Experiment Station indicate that up to 11 years of age, maturation effects have little influence on growth so that clones can be tested, repropagated and bulked up to provide a quality source of tested genetically improved material.

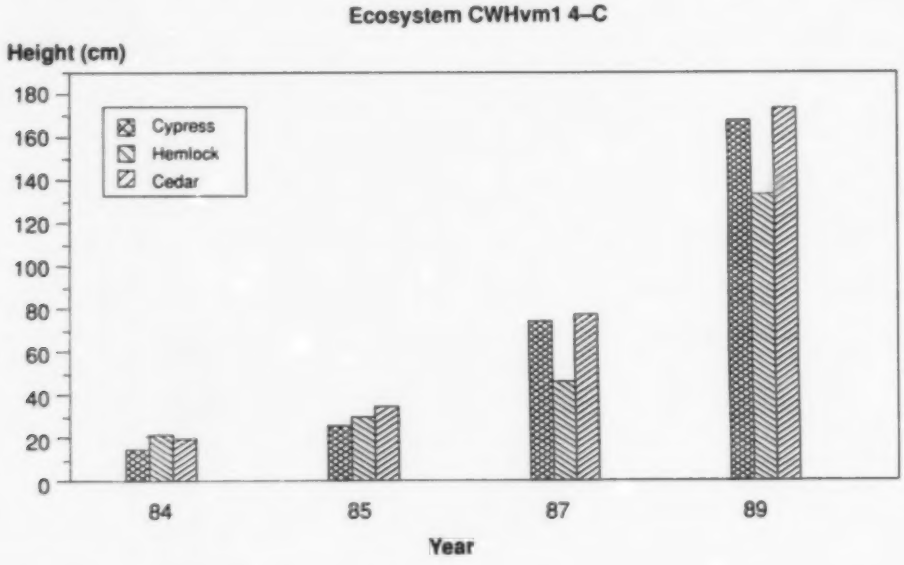

FIGURE 1. Holberg species trial: 5-year data.

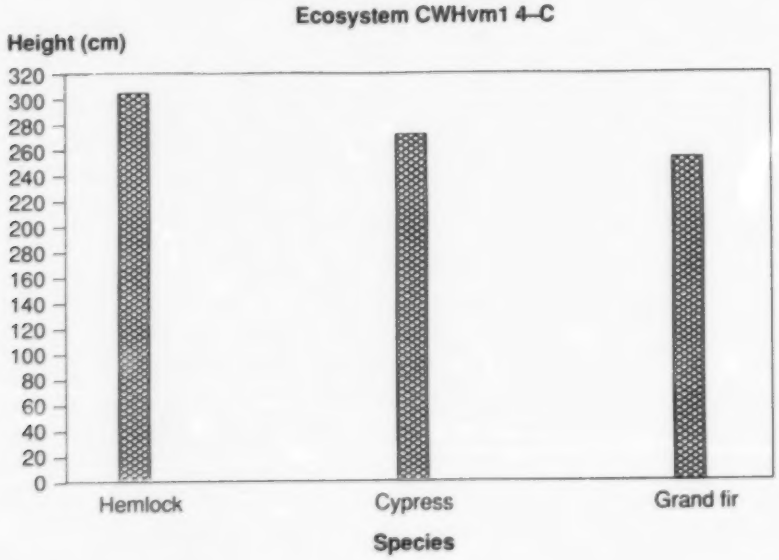

FIGURE 2. Rupert Arm species trial: 5-year data.

Clone	Volume
20	37.7
14	42.4
13	45.4
22	45.5
11	46.4
12	48.0
10	48.2
5	48.7
2	49.0
3	49.4
4	50.5
16	52.6
17	53.3
1	53.9
15	55.8
18	57.9
9	58.1
21	61.9
19	61.9
6	73.8

Clone	Height (cm)
20	50.2
3	51.6
22	53.2
14	53.9
13	53.9
11	54.2
12	54.8
2	55.1
15	55.4
4	56.0
1	56.5
17	56.8
5	56.9
16	57.6
10	57.7
6	58.7
9	59.6
21	59.7
18	60.6
19	60.8

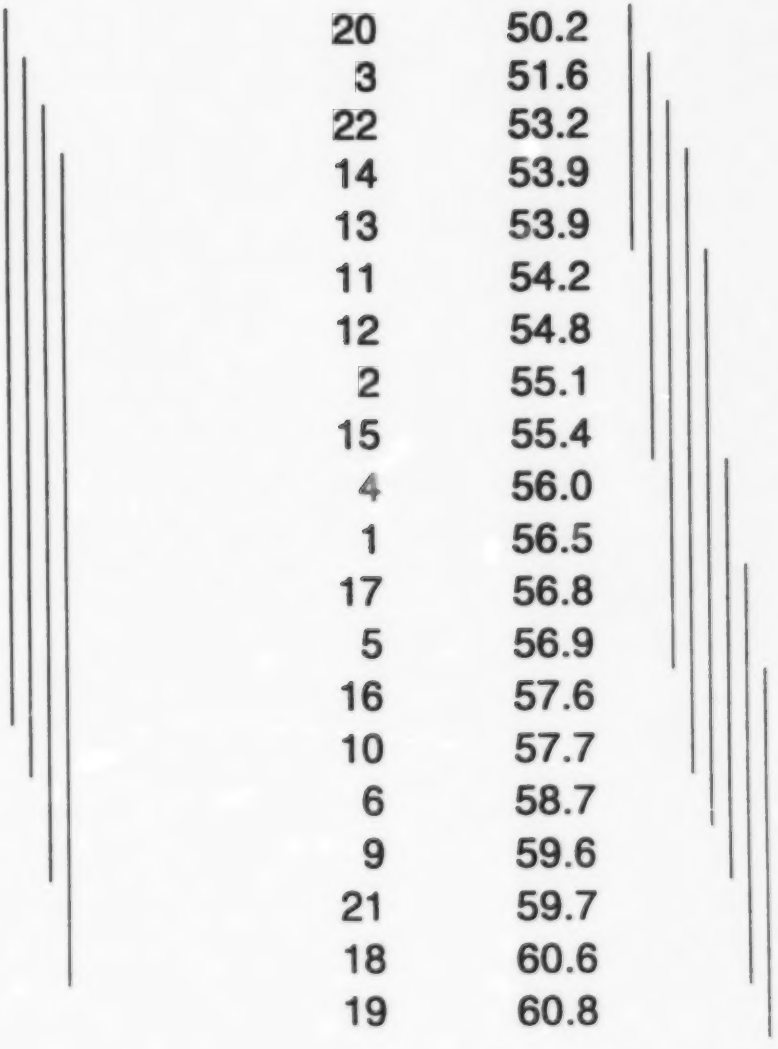

FIGURE 3. Yellow cypress clonal rankings.

The current range of tests which are underway should help in placing the management of this valuable species on a more substantial basis.

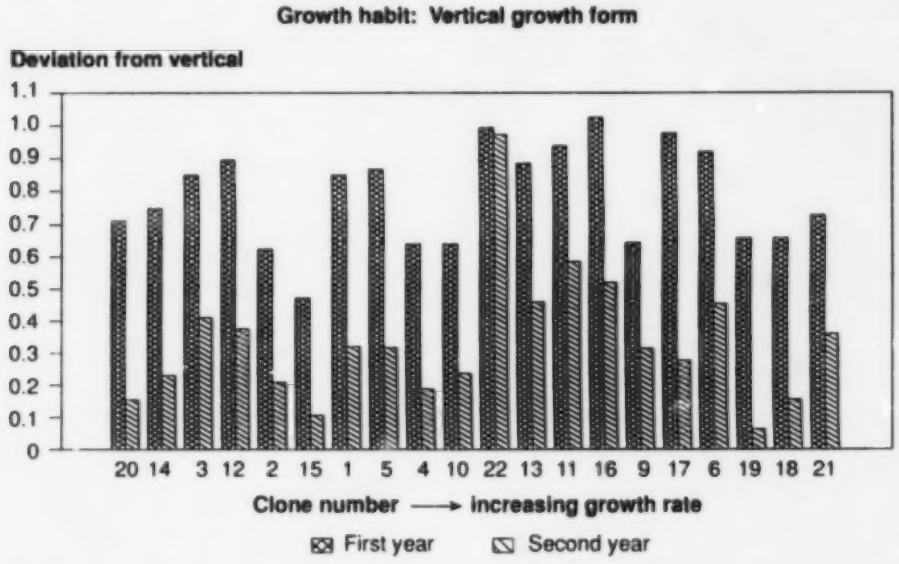

FIGURE 4. Yellow cypress clonal test.

Within-Population Variation in Yellow Cypress: Forestry Implications*

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In conjunction with Canadian Pacific Forest Products, we conducted a detailed study of morphological and growth variation on open-pollinated progeny collected from parent trees within two contiguous but ecologically distinct populations of yellow cypress (one located midslope, the other in a swamp) on Walker Mountain in the Sooke area. While the primary aim of the study was to apportion the variation encountered to parentage, site and local topography, the results obtained also have implications for the design of natural stand seed collections with respect to both seed germination and progeny growth in the nursery, and for the design of more extensive genetic trials for the species.

One study examined variation in seedling germination and height growth between sites, among parent trees within a single site, and among crown sections (top, middle and bottom thirds of the canopy) within each tree. There was generally a decline in germination percentage from the top to the lower canopy, particularly for the swamp site which had a more closed canopy than the midslope site. This suggests that the decline might be due to differences in seed maturity, as a result of shading, but more detailed studies are needed. Much of the variation in seedling height growth (measured at 4 and 9 months after germination) was found to apportion within the crown of individual trees, and there were significant differences in progeny height growth among crown sections for some trees. Indeed, variation among crown thirds (which ranged from 0 to 15%) was usually equal to or greater than the variation among parent trees or sites. This high degree of within-crown differentiation might be due to the fact that trees whose crowns are isolated from their neighbours, either horizontally or vertically, are more likely to have selfed progeny. Thus, within an uneven-aged stand there may be a continuum of mating systems, from highly outcrossed to highly selfed. Given the declining germination percentages and variability of progeny within a crown, cone collections in natural stands should probably focus on co-dominant rather than dominant trees, since co-dominant trees are more likely to have offspring resulting from outcrossing events and thus are less subject to inbreeding depression. Furthermore, collection within these co-dominant trees should be restricted to the upper thirds of the canopy.

A second study examined time trends in variation in seedling height growth (measured five times) and number of needle whorls initiated (measured 13 times) over an 8-month period. Again, most of the variation was within open-pollinated families. Variation due to sites was minimal and either increased slightly (whorl data) or decreased (height data). With time, both variation among and within open-pollinated families increased. At all times a moderate amount of variation was apportioned among open-pollinated families (15–34% for whorl data, 23–33% for height data). However, the variation among open-pollinated families increased at a slower rate than the variation within open-pollinated families, which would lead to declining estimates of heritable variation with time. The transient nature of estimates of heritable variation suggests that estimates of heritability and gain based on early nursery studies should be interpreted with caution when breeding programs are planned.

A third study compared embryos taken from seeds of varying origins: 1- versus 2-year-old, controlled cross versus open pollinated, and seed orchard (Canadian Pacific Forest Products' Saanichton Orchard) versus natural site (Walker Mountain). The only differences in size were width of the embryo at the base of the apical meristem, with the 2-year-old embryos being larger. This suggests that, at least at low elevations, a functional embryo is produced in 1 year. These embryological results are corroborated by a series of germination tests being conducted by staff at Canadian Pacific Forest Products, where germination percentages for seed 11 and 16 months after pollination were comparable. The transfer of

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* Summary of a poster which the authors were unable to present at the symposium.

material from high to low elevations for the purpose of establishing seed orchards can lead to changes in phenology, due to greater heat sums at low elevations, and this in turn can lead to a speeding up of development compared to natural stands.

DISCUSSION GROUP SUMMARIES

DISCUSSION GROUPS 1 AND 2: RESEARCH NEEDS

Operational Problems

1. We need to obtain adequate material for regeneration operationally (i.e., seeds, cuttings, micro-propagation).

   Need - to develop techniques and better procedures for providing adequate stock for regeneration.

2. We need to select better genotypes for mass propagation for reforestation (improve yield and product quality).

   Need - to undertake genetic improvement to provide better trees.
   - to characterize and maintain genetic diversity.

3. We need to improve our ecological understanding of yellow cypress.

   Need - to determine the ecological amplitude of the species.
   - to determine optimal growth conditions (in a controlled environment).
   - to determine its natural limits (field observation).
   - to experiment with transferability of stock.
   - to determine the competitive resilience of yellow cypress.

4. We need to ensure good survival and growth of the regenerating seedlings.

   Need - to conduct experiments with layering.
   - to evaluate the field performance of different stock types.
   - to evaluate the effects of different stock lifting times and the benefits of using cold-stored versus frozen stock.
   - to select clones with a higher terpeen content to discourage deer browsing.

5. We need to know the effects of stand management on the growth and yield of yellow cypress.

   Need - to establish a program of Permanent Sample Plots (orthodox).
   - to study the effects of density on growth and yield.
   - to understand the effects of various stand management regimes.

Research Needs

When defining research needs for yellow cypress regeneration, four general questions must be addressed:

1. What are our yellow cypress management objectives?
2. What do we need to know to achieve these objectives?
3. Who should undertake the research?
4. How do we muster the necessary financial resources?

The following were identified as the highest priority research needs. The listing does not denote priority.

1. the growth and yield of yellow cypress under various management regimes.
2. the protection strategies required to minimize losses to insects, disease, browsing, and competition.
3. improvement of genetic and planting stock quality.
4. seed transfer guidelines.
5. harvesting techniques and procedures required to maintain site quality.

6. basic regeneration needs of yellow cypress: e.g., species ecology, tolerance, physiology, site selection, appropriate silviculture systems, stocking levels, stand dynamics.
7. information necessary for the integration of all forest resource values (e.g., wildlife, watershed, recreation) in yellow cypress forests.
8. wood properties of second-growth yellow cypress versus old growth.
9. on-going R & D for products and markets.

Time limitations did not permit the discussion of Questions (3) and (4).

DISCUSSION GROUPS 3, 4 AND 5: SILVICULTURE AND SITE RECOMMENDATIONS

1. Reforestation goals
   - first priority: to retain yellow cypress as a component of stands in which it was previously harvested.
   - to co-ordinate trials out of its normal range to improve quality and volume of cypress.
   - to maintain species diversity to reduce the risk from insect, disease, and global warming.
2. Site types
   - planting on CWHmm (vm higher elevation), MH sites is recommended.
   - planting on wet sites with deep organic layers; medium nutrient regime and fresh moisture regime are recommended.
   - expand traditional site selection to lower-elevation, readily accessible sites which are nutritionally poor to medium.
3. Stock type options
   - prefer seedlings, will take cuttings (with some future potential for emblings).
   - 1-0 plug 313's have a proven record .
   - consider options for transplants and, perhaps, larger stock.
   - consider 50/50 combination of stecklings and seedlings to ensure genetic diversity.
4. Planting/stocking density
   - plant in fall or spring; fall planting should be early; if good planting conditions in the spring are unusually late, consider fall planting.
   - do not rely on natural regeneration since it is unpredictable.
   - plant at high density to produce higher quality product (e.g., up to 3000 sph).
   - 1200–2000 sph may control understory competition, and will improve crown form and encourage natural pruning.
   - use vexar tubes for protection from deer browsing where necessary.
   - other options may include group planting or group selection.

5. Site preparation
    - burning considered for low-elevation (up to 600 m), gentle slopes where slash reduction is required and high vegetation competition is expected; burn to reduce L and F layers.
    - mechanical and chemical site preparation not deemed necessary on "traditional" yellow cypress sites.
6. Stand tending
    - hard to justify expenditures on the poorer sites, but such expenditures may be necessary to ensure a flow of wood.
    - there is a potential for high value commercial thinning products, but wounding may be too risky to justify thinning.
    - pruning is not currently economical; it is limited to trials on nearby, high productivity sites.
    - leave the stands dense, at least 2000 sph.
    - clip multiple leaders.
    - fertilization not desirable.

WRAP-UP COMMENTS

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I believe there are two main take-home messages from this workshop:

- Yellow cypress should be tried on a wider range of sites; and
- The value of the product justifies more extensive use of the resource.

The workshop has summarized:

1. the understanding of the nature of yellow cypress values: it produces clear wood of uniform colour and strong natural durability, because of the presence of its natural fungicides and insecticides, nootkatin and chamic acid.
2. the extent of operational experience: yellow cypress is a resilient, shade-tolerant species; we can plant seedlings or rooted cuttings; yellow cypress can be planted in densities varying from 1000 to 3000 per hectare; yellow cypress seems to do well on sites that have been prescribed burned.
3. the status of current research: we have basically just begun; information is available on the physiological tolerance, ecology, and genetics of yellow cypress, and on some of the pests (e.g., cone mites) and disease, but much more research is needed.

Some discussion has centred on the availability of funds for yellow cypress research. Coastal Regeneration Industrial Co-operative has dedicated $700 000–800 000 over 3 years for research on seed germination, seedling culture, ecophysiology, and clonal screening.

Thanks to everyone associated with this workshop, particularly Dan Lousier, Kathy Banky and FRDA.